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No. 31, September 1962

Mammals of the Lowland Rain-Forest of North Borneo

by

D. Dwight Davis

Chicago Natural History Museum

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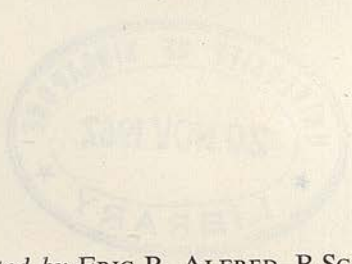
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Edited by ERIC R. ALFRED, B.Sc.
Curator of Zoology, Singapore National Museum

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Mammals of the Lowland Rain-Forest of North Borneo

By D. DWIGHT DAVIS

Chicago Natural History Museum

(Received November, 1961)

INTRODUCTION

THIS REPORT is an account of all mammals known to occur in the lowland areas of the Colony of North Borneo. Above 3,000 feet on the massifs of Kinabalu and Trus Madi the mammalian fauna is so different that it forms an essentially distinct problem, and one that to me at least is far less interesting than that of the rich fauna of the lowland tropical rain-forest.

This work is based largely on specimens and field data collected by three field parties from Chicago Natural History Museum that visited North Borneo between 1929 and 1956. These data were supplemented by material borrowed from other American museums and by an examination, unfortunately very cursory, of North Bornean material in the National Museum in Singapore and the Sarawak Museum in Kuching. I have tried to include all pertinent published information in order to bring our knowledge of this fauna up to date.

Borneo is of unusual biological interest. Here the rich flora and fauna of the Oriental tropics are less disturbed by man than in any other area of comparable size. Thousands of square miles of continuous rain-forest provide what is perhaps the most favorable terrestrial environment on earth for both plant and animal life. Among mammals, some of the most generalized of living forms flourish side by side with some of the most specialized. The island lies in the area that has long been recognized as presenting the most complex and difficult of all zoogeographic problems.

It is unlikely that any species of North Bornean mammal remains undiscovered; no valid new species has been described since 1938, no species of non-flying mammal since 1903. This indicates that the first step in understanding the mammals of Borneo—the primary inventorying of the fauna—has been completed. Attention may now turn to other facets of the problem—testing and synthesizing the taxonomic hypotheses and exploring the ecological relationships of the mammals. This report is a first attempt at such an orientation.

ACKNOWLEDGEMENTS

Much indispensable assistance was provided during our field work in Borneo. The Chicago Natural History Museum is deeply obligated to the Forestry Department of North Borneo, particularly to Messrs. G. S. Brown and F. V. Webster in 1950, and to Messrs. G. Carson and G. H. S. Wood in 1956, for innumerable favors to Museum personnel. The Bombay Burmah Trading Corporation, Ltd., provided facilities and transportation both in 1950 and 1956, and we are further grateful to Messrs. O. C. Finch, John Shelley, and J. D. H. Hedley for many personal favors. Mr. Lai Foo Kim, of United Timbers, Ltd., provided transportation to and from the Deramakot camp and facilities at the camp. Mr. Tom Harrison, Curator of the Sarawak Museum, provided us with a trained Iban collector in 1950 and again in 1956, in addition to

many personal kindnesses. Messrs. M. F. W. Tweedie and C. A. Gibson-Hill, formerly of the National Museum, Singapore, were helpful during our stay in Singapore and granted permission to study materials under their care.

The U.S. National Museum and the Museum of Comparative Zoology loaned certain specimens for use in this study. Prof. C. G. G. J. van Steenis, Rijksherbarium, Leiden, identified plant materials submitted to him. Mr. Harry Nelson, Roosevelt University, Chicago, and Mr. Henry S. Dybas, Associate Curator of Insects, Chicago Natural History Museum, identified arthropod fragments in stomach contents. Dr. Alan Solem, Assistant Curator of Lower Invertebrates, Chicago Natural History Museum, identified molluscs from the stomachs of mammals. My assistant, Miss Phyllis Wade, prepared the drawings illustrating this report and was helpful in many other ways. I am indebted to Mr. Philip Hershkovitz, Curator of Mammals, Chicago Natural History Museum, for assistance and for stimulating discussions during the course of the study. Dr. Karl F. Koopman read the manuscript and made many valuable suggestions.

METHODS

During our field work in both 1950 and 1956 data in addition to the standard skin and skull were collected. A running diary was kept of all mammals observed, including any pertinent ecological data. In addition to standard flesh measurements, the weight

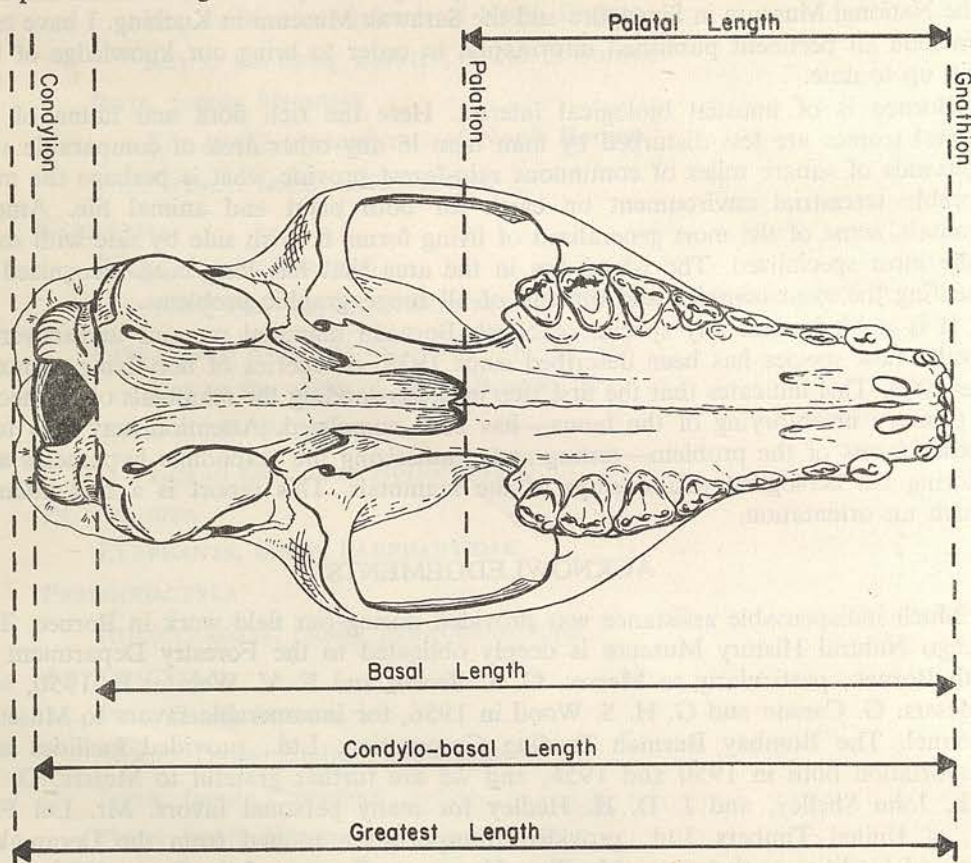


Figure 1. Standard skull measurements as used in this study. Zygomatic breadth (not shown) is maximum breadth across zygomatic arches.

of each collected mammal was recorded. Weights were made with spring balances checked for accuracy before they were taken into the field. Each individual was examined for ectoparasites, which were preserved separately. All food-containing stomachs were preserved, and all females were examined for pregnancy or signs of lactation, and all pregnant uteri preserved.

All measurements used in this study, both flesh and bone dimensions, were made by me unless otherwise stated. Skull measurements up to 150 mm. were made with the same Vernier calipers graduated to 0.1 mm. The smallest skulls were measured under a binocular microscope. Lengths beyond 150 mm. were measured with a large calipers and meter stick. Tooth measurements were made at the alveoli, not at the crown. The nomenclature used for skull measurements is that recommended by Thomas (1905, *Proc. Biol. Soc. Wash.*, 18; see also fig. 1). "Greatest length" is the distance between lines *perpendicular to the toothrow*, taken not farther divergent from the midline than either condylion.

When the sample is large enough (usually 10 or more specimens), important measurements are expressed as the mean, the standard error of the mean, and the observed range, written, e.g., 30.3 ± 0.21 (28.1–32.4). The standard error of the mean is the range on either side of the sample mean that may be expected to include 67 per cent of any sample means drawn from the same population.

For the most part, colors are described in general terms. In a few instances Ridgeway names are used for colors, and such names are capitalized.

Stomach contents were washed by placing the material on fine-meshed cheesecloth and running a stream of water through it for a few minutes. The washed material was then placed in water in a finger bowl and sorted under a 9-power binocular microscope. After sorting, the relative bulk of each item or food category was estimated by eye; the bulk of the entire food organism, rather than the fragments actually recovered, was used in making estimates. Except in a few instances it was impractical to identify prey animals down to the species level.

Nomenclature in general follows Chasen's *Handlist of Malaysian Mammals* (1940). I have not attempted to compile complete synonymies. In most instances only the original description and the first appearance of the currently accepted combination are cited, except where my views differ from those of Chasen. In the latter case the name or combination appearing in the *Handlist* are also given.

HISTORY OF WORK ON NORTH BORNEAN MAMMALS

North Borneo has been less fortunate, from the standpoint of faunal research, than the adjoining colony of Sarawak. The existence of the Sarawak Museum in Kuching, plus the active collecting activities of such colonial officials as A. H. Everett and Charles Hose, have resulted in a considerable accumulation of specimens and information on the mammalian fauna of Sarawak. In North Borneo the lofty isolated massif of Mt. Kinabalu, easily accessible from the coast, has long acted as a magnet to collectors, but the lowland rain-forest has received little attention.

Recorded knowledge of the mammals of the North Bornean rain-forest may be said to begin with Magellan's visit in 1521; Pigafetta, his chronicler, reported the existence of elephants. Systematic work on the fauna, largely by the staff of the British Museum, began about the middle of the last century. J. E. Gray, Albert Günther, and particularly Oldfield Thomas, described 15 North Bornean forms between 1846 and 1902. Collections were made in the vicinity of Sandakan by W. B. Pryer in 1881, on Mt. Kinabalu by John Whitehead in 1887–1888, and at various points along the coast

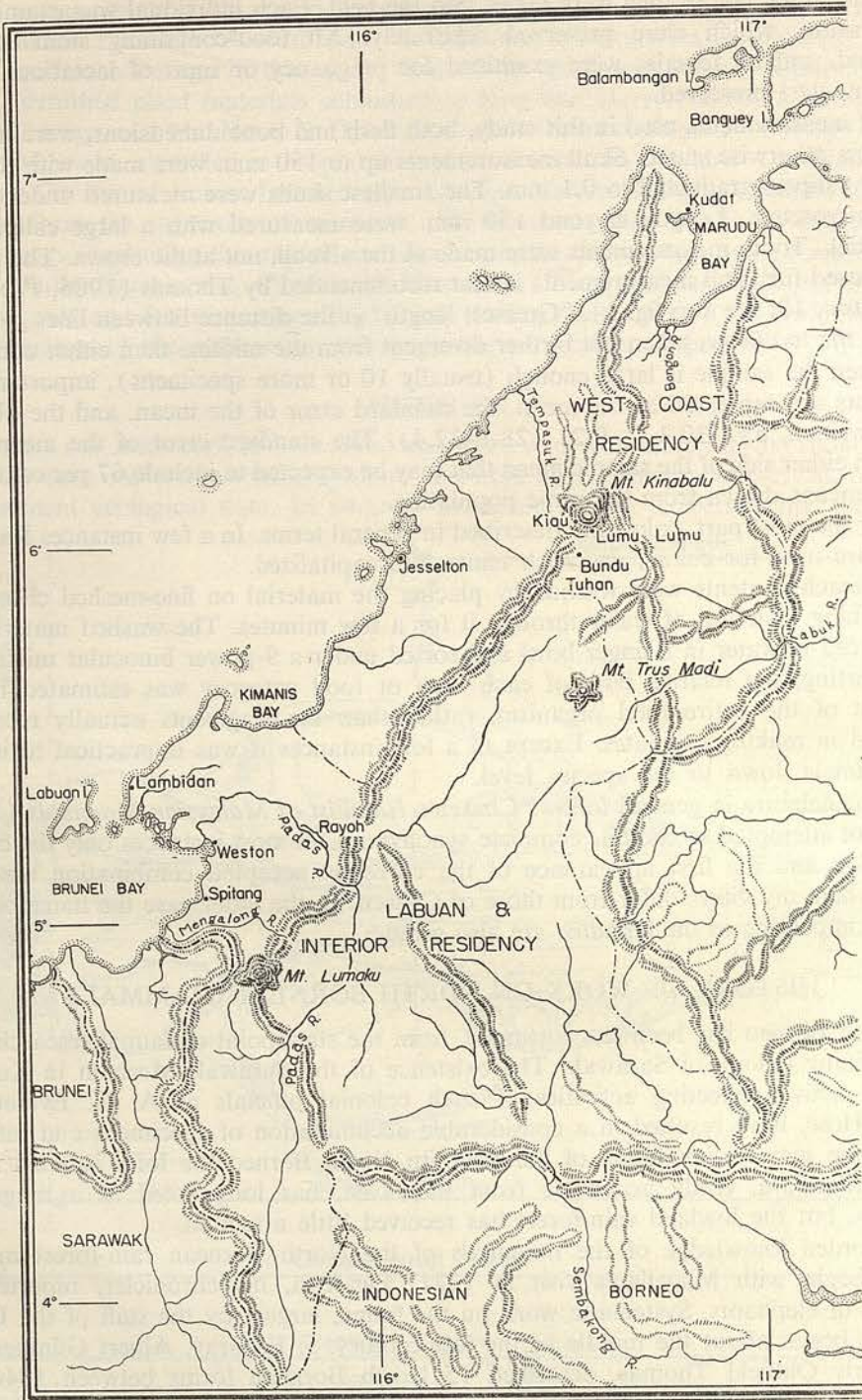
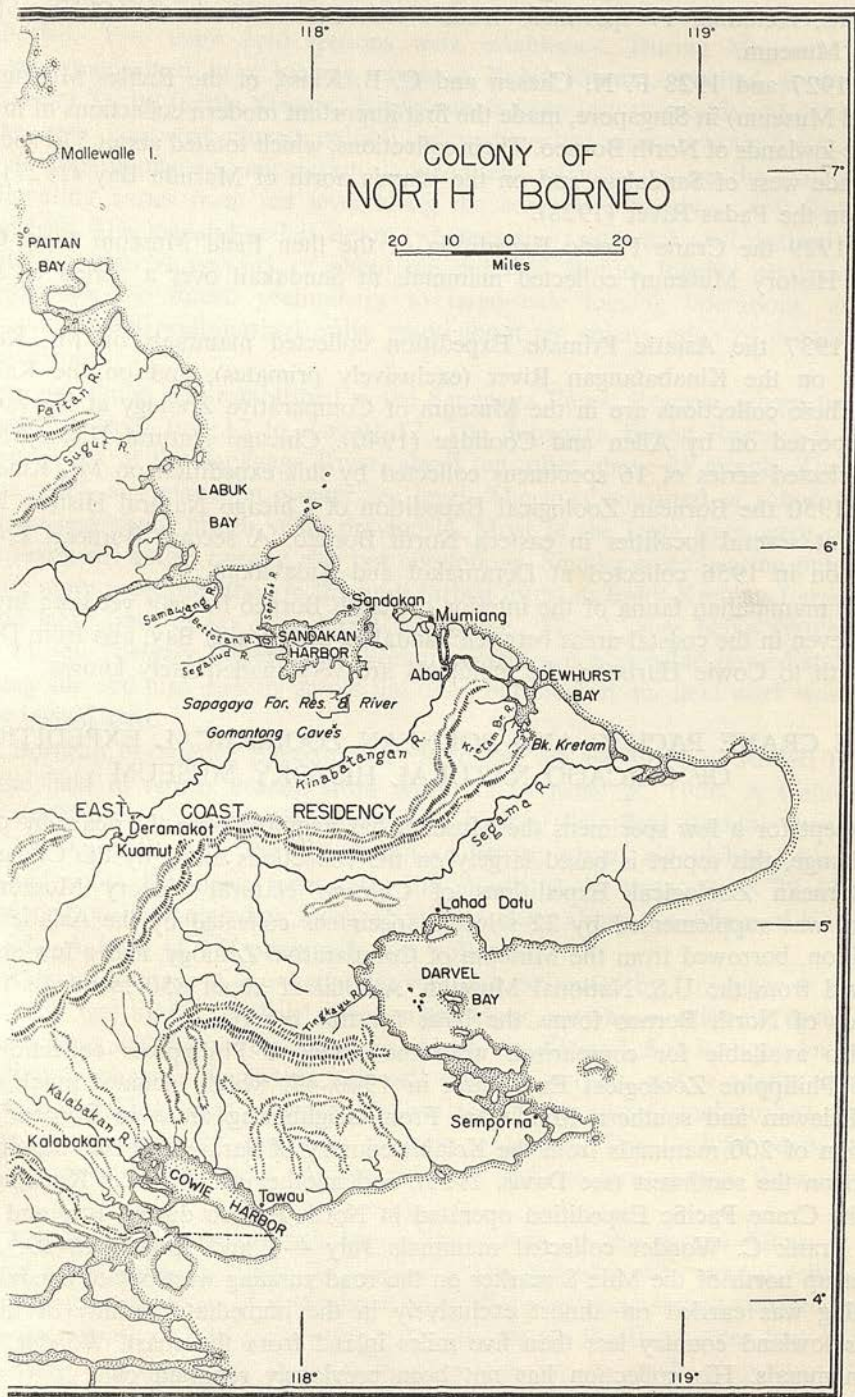


Figure 2. Colony of North Borneo, showing



by A. H. Everett in 1892–1893. A small selection of the historically important Everett collections, including 17 specimens from North Borneo, is in the Chicago Natural History Museum.

In 1927 and 1928 F. N. Chasen and C. B. Kloss, of the Raffles Museum (now National Museum) in Singapore, made the first important modern collections of mammals from the lowlands of North Borneo. Their collections, which totaled about 575 specimens, were made west of Sandakan and on the islands north of Marudu Bay (1927) and at Rayoh on the Padas River (1928).

In 1929 the Crane Pacific Expedition of the then Field Museum (now Chicago Natural History Museum) collected mammals at Sandakan over a period of about a month.

In 1937 the Asiatic Primate Expedition collected mammals on Mt. Kinabalu, at Abai on the Kinabatangan River (exclusively primates), and on the Kalabakan River. These collections are in the Museum of Comparative Zoology at Harvard; they were reported on by Allen and Coolidge (1940). Chicago Natural History Museum has a selected series of 16 specimens collected by this expedition on Mt. Kinabalu.

In 1950 the Bornean Zoological Expedition of Chicago Natural History Museum worked at several localities in eastern North Borneo. A second Bornean Zoological Expedition in 1956 collected at Deramakot and Kalabakan.

The mammalian fauna of the interior of North Borneo has not yet been investigated, and even in the coastal areas between Sandakan and Brunei Bay, and from Dewhurst Bay south to Cowie Harbour, the mammals are very inadequately known.

THE CRANE PACIFIC AND BORNEAN ZOOLOGICAL EXPEDITIONS OF CHICAGO NATURAL HISTORY MUSEUM

Except for a few specimens the Museum has acquired over the years by purchase or exchange, this report is based largely on the collections made by the Crane Pacific and Bornean Zoological Expeditions of Chicago Natural History Museum. This material was supplemented by 22 selected specimens collected by the Asiatic Primate Expedition, borrowed from the Museum of Comparative Zoology, and a few specimens borrowed from the U.S. National Museum. A total of about 850 mammals from the lowlands of North Borneo forms the basis for this report.

Also available for comparison were the extensive Philippines collections made by the Philippine Zoological Expedition in 1946–47, which includes much material from Palawan and southern Mindanao. From neighboring areas in Borneo I had a collection of 200 mammals from the Kelabit country of Sarawak, which adjoins North Borneo on the southwest (see Davis, 1958), and another of 150 from Kuching.

The Crane Pacific Expedition operated in North Borneo during July and August, 1929. Frank C. Wonder collected mammals July 4–9 and August 10–29. A camp was set up north of the Mile 8 marker on the road running west out of Sandakan, and collecting was carried on almost exclusively in the immediate vicinity of the camp. This is lowland country less than five miles inland from the coast. Wonder collected 106 mammals. His collection has not been previously reported on.

The Bornean Zoological Expedition 1950, under the joint leadership of Robert F. Inger and myself, operated in North Borneo from early April to early September.

A trained Iban collector was with us throughout our stay. A total of 352 mammals was collected. Two main field stations were established. During May and June a station was maintained in a logging camp at Bukit Kretam, situated at the mouth of the Kretam Kechil (Little Kretam) River, which flows into the south end of Dewhurst Bay. The area consisted almost entirely of undisturbed primary rain-forest, with a section of nipa-mangrove association immediately adjacent along the bay and the river. Elevation varies from sea level along the bay shore to about 450 feet on the highest ridges. The lowland soil is damp, whereas the ridges are well drained and the soil relatively drier. A network of about ten miles of 50-foot logging roads had been cleared through the forest, preliminary to large-scale logging operations, and this, together with several well-marked trails, made about ten square miles of primary forest readily available.

A second station was established in the Sapagaya Forest Reserve, where field work was carried on from July 13 to August 12. The Sapagaya Forest Reserve is situated on the west bank of the Sapagaya River, about ten miles above its mouth. There is no important relief, and elevation is near sea level. The area consisted of rain-forest that had been logged about fifteen years previously. Most of the large trees were removed, and as a result the forest canopy was not continuous. Smaller trees bearing pulpy fruits were much more numerous than in the undisturbed forest at Bukit Kretam. Large woody lianas and large trees of no commercial value (e.g., *Ficus*) were being systematically removed by the Forestry Department. Primary forest was accessible immediately north of the camp site and also directly across the river, but most of our field work was carried out in the logged area.

The Bornean Zoological Expedition 1956, under the leadership of Robert F. Inger, was in the field in North Borneo from April 22 to June 28, 1956. A trained Iban collector worked on mammals throughout this period. Two field stations were set up, the first at Deramakot on the Kinabatangan River, about six airline miles below Kuamut and about 80 airline miles from the mouth of the river (April 22–May 18), and the second on the Kalabakan River about two miles above the village of Kalabakan (June 2–28). A total of 121 mammals was collected.

The Deramakot area is low and relatively flat, estimated by Dr. Inger at no more than 100–150 feet above sea level. Numerous ridges, varying in different parts of the area from 150 to 850 feet in elevation, rise above the flatland. Soil is damp and clayey in the flatland, whereas the ridges are well drained and the soil is sandy. Both the lowland and the ridges support dense tropical rain-forest, mostly undisturbed by man, with large trees sufficiently numerous to form a canopy. The lowland forest is rich in vines and undergrowth; vines are less common and the undergrowth thinner on the ridges.

The Kalabakan camp was situated at the mouth of the Sungei Tibas, a small tributary of the Kalabakan River. The region is low but with very rugged relief, some ridges reaching an elevation of a thousand feet. The area immediately surrounding the camp site was being or had been logged; practically all the large trees had been removed, leaving the remaining forest without a canopy. A patch of primary forest, similar in physiognomy to the forest at Bukit Kretam and Deramakot, was available about half a mile upstream from the Sungei Tibas camp. Most mammal collecting was in the logged-over area.

THE PHYSICAL ENVIRONMENT

The colony of North Borneo lies between $7^{\circ} 2'$ and $3^{\circ} 42'$ N. latitude, and has an area of about 31,000 square miles. The colony is divided by a group of north-south mountain ranges into a larger eastern part and a smaller western part. The most conspicuous physical feature is the lofty massif of Mt. Kinabalu, which rises to 13,455 feet, and lies at the northern tip of the Crocker Range. The second highest elevation is Mt. Trus Madi, approximately 8,000 feet. The eastern area consists of a series of river basins, with a general northeast orientation, separated from each other by ranges of hills. The largest of these basins is that of the Kinabatangan River. The western area, west of the Crocker Range, consists of a narrow coastal plain about 25 miles wide extending along the west coast. It is drained by numerous short rivers flowing in a general northwesterly direction into the South China Sea. Maps show a large interior plateau lying between the Crocker and Maitland mountain ranges, draining south into the Sembakong River. This interior plateau has not been explored zoologically.

In the eastern area the native peoples are seafarers or hunters and foodgatherers, and the population is thinly distributed. On the west coast the aborigines practice a primitive shifting agriculture and the population is much denser.

Tropical rain-forest extends from sea level to an elevation of about 3,000 feet. Above 3,000 feet the tropical forest is replaced by montane rain-forest, including mossy forest, and finally by subalpine forest and alpine scrub. The character of the fauna varies with this altitudinal zonation (Pendlebury and Chasen, 1932). Only the tropical rain-forest (the Lowland Zone of Pendlebury and Chasen) is considered here.

Tropical ever-green¹ rain-forest originally covered by far the greater part of North Borneo. This primary cover has been disturbed somewhat by man, much less so in the East Coast Residency than in the west. In the west the forest has been seriously damaged by the aborigines, who cut and burn large tracts of forest in connection with a destructive system of shifting agriculture (Plate 1). Here the original forest has been replaced by secondary forests with entirely different predominant vegetational elements (Keith, 1947). Aerial reconnaissance of the East Coast Residency, from Sandakan south to Lahad Datu and west beyond Kuamut, indicated that in 1950 remaining forest of original type was practically continuous and uninterrupted. The head of the Forestry Department at Sandakan estimated, however, that about five per cent of the land area of North Borneo had been logged, and probably more interfered with by aborigines in one way and another (personal communication).

STRUCTURE OF THE FOREST

The North Bornean rain-forest forms a three-dimensional matrix within which the associated animal life lives. The ecological relationships of the mammalian fauna must be considered in relation to this matrix. The forest is composed of some 3,000 species of trees (Browne, 1955), stratified in three layers, a distinct and easily recognizable top story and less easily separable middle and lower stories (fig. 3).

The top story.—The forest is dominated by huge trees of many species, from 100 to 200 feet or more in height and with trunks three to seven feet in diameter. Although numerous in species, they are remarkably uniform in general appearance. The crowns of these trees form the forest canopy, although they are usually well separated from each other and do not form a continuous layer. Their boles rise straight and unbranched for

1. This term is used in the botanical sense, which refers to absence of a season during which trees are bare. It has no relation to coniferous forest.

80 feet or more, usually supported at the base by plank-like buttresses. These trees are chiefly dipterocarps (family Dipterocarpaceae), an essentially Indo-Malayan family, and the forest type is commonly called Ever-green Dipterocarp Forest. According to Keith (1947) dipterocarp species make up 60 per cent of the (commercial) timbers in this area. Richards (1952) found that dipterocarps formed at least 44 per cent of all trees 16 inches or more in diameter in the Mt. Dulit region in Sarawak.

Strangling figs (various species of *Ficus*, Plate 3) are of no commercial importance and were not considered by Keith, but they are numerous and form an important element of the forest. Adult stranglers reach tremendous size, their crowns participating in forming the canopy. The fruits of the several species of *Ficus* are extremely important to frugivorous mammals and birds. In general pomiferous fruits are not numerous.

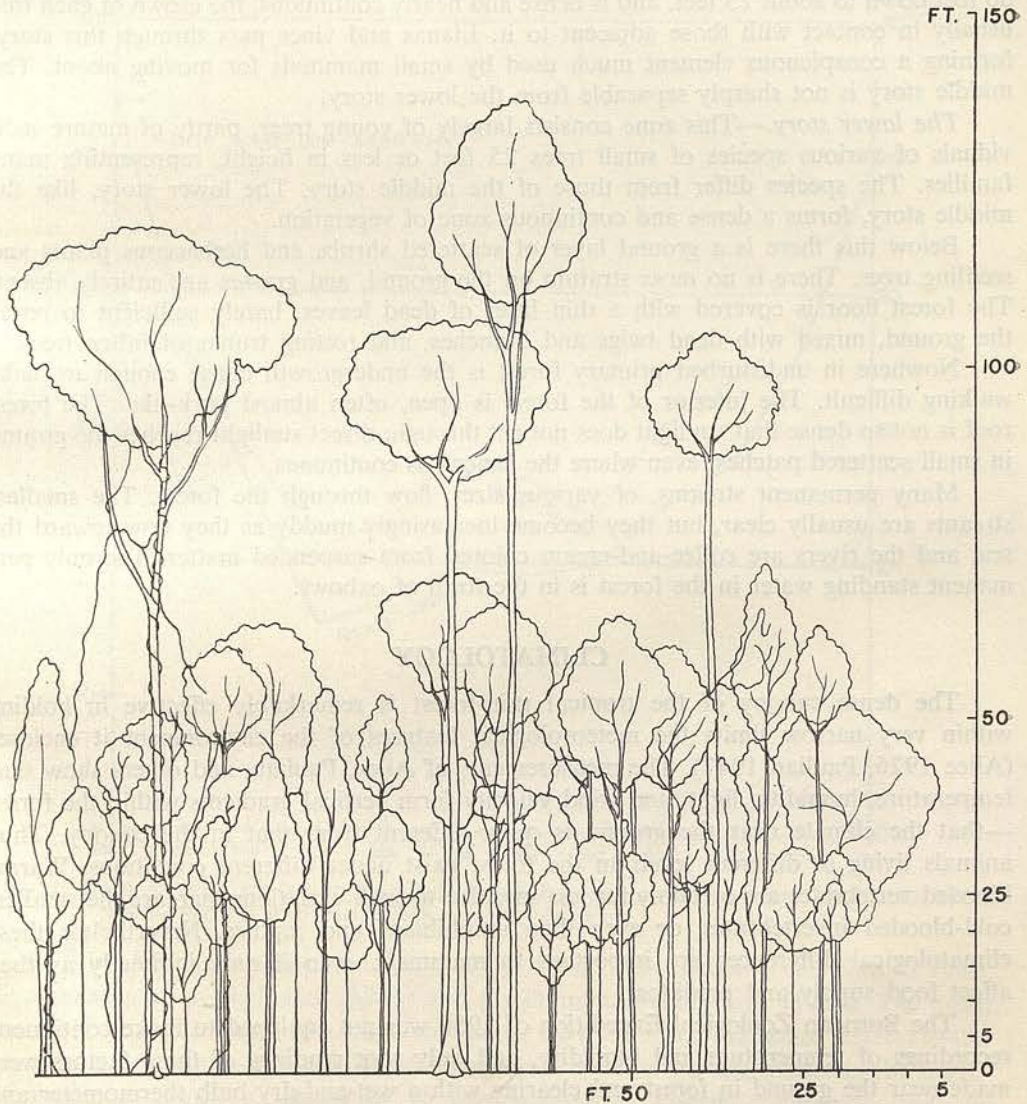


Figure 3. Profile diagram of Bornean dipterocarp rain-forest. Only trees over 25 feet high are shown. Slightly modified from Richards 1952.

The crowns of these trees are heavily infested with epiphytic ferns, some of which attain immense size, and orchids and bromeliads are present to a lesser extent. Woody lianas of various sizes, some thicker than a man's thigh, hang down from the canopy, and more slender vines and other climbing plants are common. These climbers tie the forest together, forming important and much-used highways along which arboreal animals travel. They are less prominent in undisturbed dipterocarp forest than in disturbed forests where other tree species predominate (Keith, 1947).

The middle story.—Beneath the top story is a middle story composed of smaller trees whose tops reach approximately to the underside of the canopy. Immature individuals of the giant trees are represented, but this layer is composed chiefly of various species of trees of smaller size, representing many families. This zone extends from about 60 feet down to about 25 feet, and is dense and nearly continuous, the crown of each tree usually in contact with those adjacent to it. Lianas and vines pass through this story, forming a conspicuous element much used by small mammals for moving about. The middle story is not sharply separable from the lower story.

The lower story.—This zone consists largely of young trees, partly of mature individuals of various species of small trees 25 feet or less in height, representing many families. The species differ from those of the middle story. The lower story, like the middle story, forms a dense and continuous zone of vegetation.

Below this there is a ground layer of scattered shrubs and herbaceous plants and seedling trees. There is no moss stratum on the ground, and grasses are entirely absent. The forest floor is covered with a thin litter of dead leaves, barely sufficient to cover the ground, mixed with dead twigs and branches, and rotting trunks of fallen trees.

Nowhere in undisturbed primary forest is the undergrowth dense enough to make walking difficult. The interior of the forest is open, often almost park-like. The forest roof is not so dense that sunlight does not get through; direct sunlight reaches the ground in small scattered patches, even where the canopy is continuous.

Many permanent streams, of various sizes, flow through the forest. The smallest streams are usually clear, but they become increasingly muddy as they flow toward the sea, and the rivers are coffee-and-cream colored from suspended matter. The only permanent standing water in the forest is in the form of oxbows.

CLIMATOLOGY

The dense canopy of the tropical rain-forest is remarkably effective in holding within very narrow limits the meteorological features of the environment it encloses (Allee 1926, Paulian 1947). The measurements of Allee, Paulian, and others show that temperature, humidity, light, and wind velocity form vertical gradients within the forest—that the climate near the ground is quite different from that in the canopy. Thus animals living at different levels in the forest exist under different conditions. Warm-blooded vertebrates are certainly far less sensitive to such variations than are the smaller, cold-blooded invertebrates, or even than amphibians and reptiles. Nevertheless these climatological differences are important to mammals, even if only indirectly as they affect food supply and predators.

The Bornean Zoological Expedition of 1950 was not equipped to make continuous recordings of temperature and humidity, and only spot readings of these factors were made near the ground in forest and clearing with a wet-and-dry bulb thermometer and a sling psychrometer. The Bornean Zoological Expedition of 1956 was equipped with

a Bristol Recording Thermohumidigraph, which was used to chart temperature and humidity at Deramakot and Kalabakan. The thermohumidigraph was calibrated in the field by means of a sling psychrometer.

Rainfall.—Two sets of rainfall data are available for Sandakan: daily records for the 23-year period 1918–1940, made by H. G. Keith; and data for the 8-year period 1947–1955, from Malayan Meteorological Service records. Means of the Keith records are significantly higher than those of the Meteorological Service, but since they represent the longest available continuous series of readings I have used them in preference to the more recent figures. For Jesselton, records are available only for the 1947–1955 period.

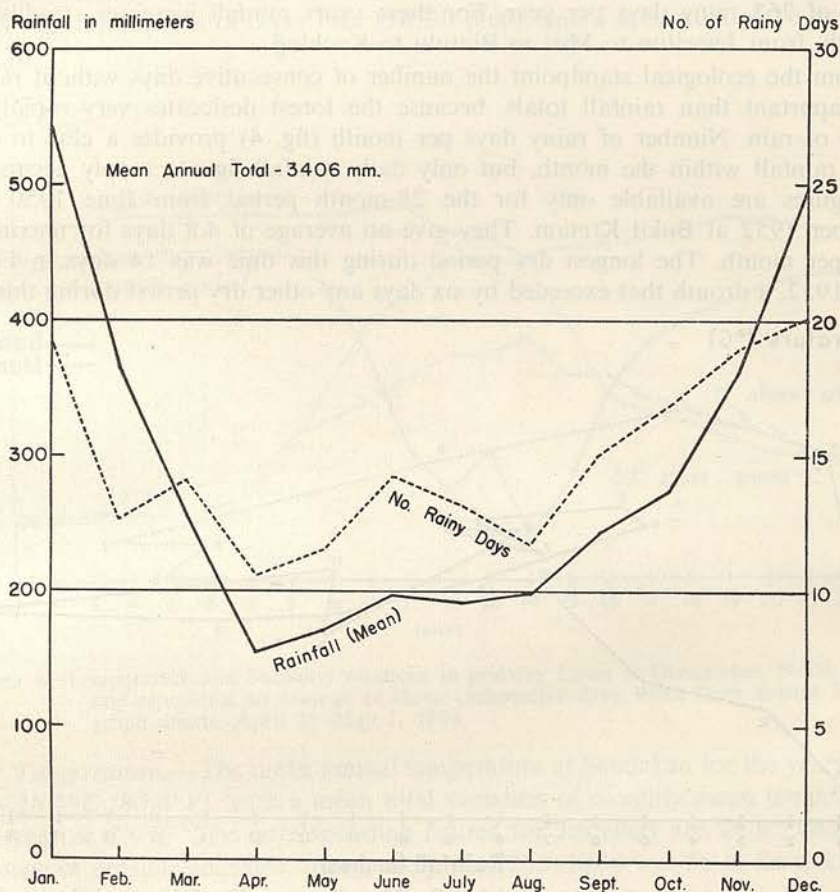


Figure 4. Mean monthly rainfall at Sandakan, North Borneo, for the 23 years 1918–1940. From rainfall records in Forestry Department, Sandakan.

At Sandakan mean annual rainfall was 3406 mm. (134 inches) from 1918 to 1940, with a maximum of 4431 mm. (1918) and a minimum of 2205 mm. (1919). The mean from 1947 to 1955 was 3023 mm., maximum 3313 (1950), minimum 2507 (1949). There is no dry season, although rainfall follows a definite seasonal pattern. The north-east monsoon brings a maximum of precipitation in December-January, and the minimum occurs in April-August (fig. 4). The mean number of rainy days per year for

1918–1940 was 178, maximum 211 (1935), minimum 131 (1930); for 1947–1955 the mean was 181, maximum 232 (1954), minimum 139 (1947). The temperature-rainfall relations for Sandakan are shown in the accompanying graph (fig. 5).

Jesselton has slightly less rain than Sandakan: the mean 1947–1955 was 2845 mm. (112 inches), maximum 3429 (1954), minimum 2337 (1951). Mean number of rainy days 1947–1955 was 199, maximum 251, minimum 162. The seasonal pattern is the reverse of that at Sandakan, with maximum precipitation in the period June–November, and the minimum January–March.

Rainfall appears to be significantly less in North Borneo than farther south in Sarawak. The 1947–1955 mean for Kuching was 3871 mm. (152 inches), with an average of 263 rainy days per year. For these years rainfall increases steadily toward the south, from Jesselton to Miri to Bintulu to Kuching.

From the ecological standpoint the number of consecutive days without rain is far more important than rainfall totals, because the forest desiccates very rapidly in the absence of rain. Number of rainy days per month (fig. 4) provides a clue to distribution of rainfall within the month, but only daily rainfall figures supply accurate data. Such figures are available only for the 28-month period from June 1950 through September 1952 at Bukit Kretam. They give an average of 4.8 days for maximum dry period per month. The longest dry period during this time was 14 days in February–March 1952, a drouth that exceeded by six days any other dry period during this time.

Temperature (°C)

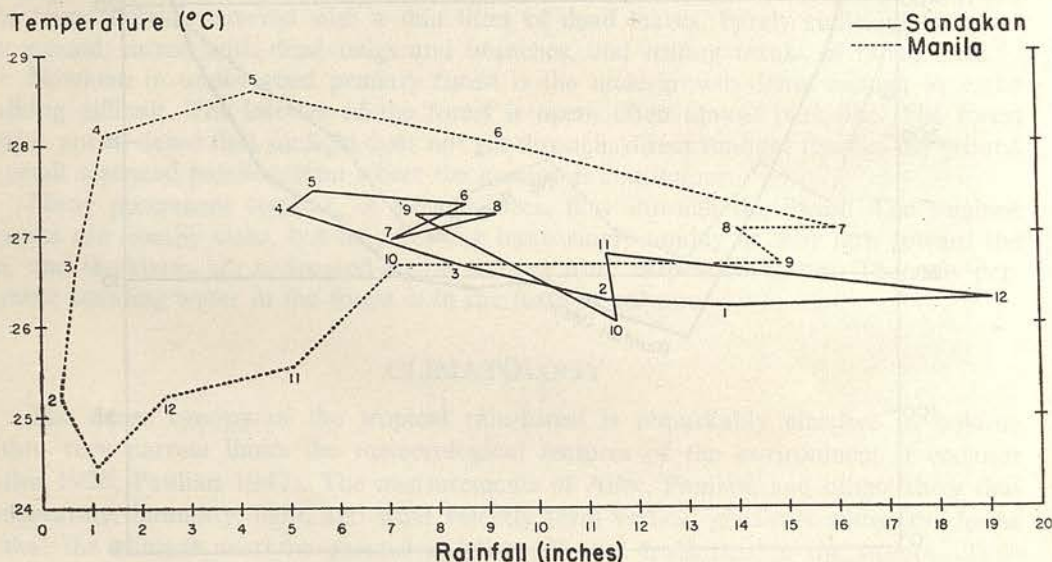


Figure. 5. Climographs for Sandakan and Manila. The climate at Manila is much less uniform than at Sandakan. The numerals 1–12 on the graphs refer to the months of the year. Sandakan data for the years 1947–54; Manila data from Allee 1926.

Humidity.—Mean relative humidity at Sandakan in 1954 was 86.0 per cent, with a mean range of 33.8. The corresponding figures for Jesselton are 84.4 per cent, mean range 30.9.

Autographic charts were made inside the primary rain-forest at Deramakot on April 25–30, 1956. The first three days the Thermohumidigraph was placed 5 feet above ground, in the lower story; the following three days 50 feet above ground, in the

middle story of the forest. The usual precautions were taken against exposing the instrument to direct rays of the sun. The means of the resulting readings are shown in fig. 6. In the lower story the diurnal range of mean humidity was 8 per cent (89–96), with the minimum at 2:00 p.m. and the maximum at 10:00–11:00 a.m. In the middle story the range was 37 per cent (55–91), with the minimum at 2:00 p.m. and the maximum at 5:00–7:00 a.m. Relative humidity varied inversely with temperature.

Parallel spot readings of relative humidity in rain-forest and adjoining clearing were made with a wet-and-dry bulb thermometer at Bukit Kretam in June, 1950. Twelve such readings, made over a period of seven days and at various hours between 8:00 a.m. and 10:30 p.m., show a mean difference between forest and clearing of 10 per cent, with a minimum of 0 per cent (10:30 p.m.), and a maximum of 18 per cent (3:30 p.m.).

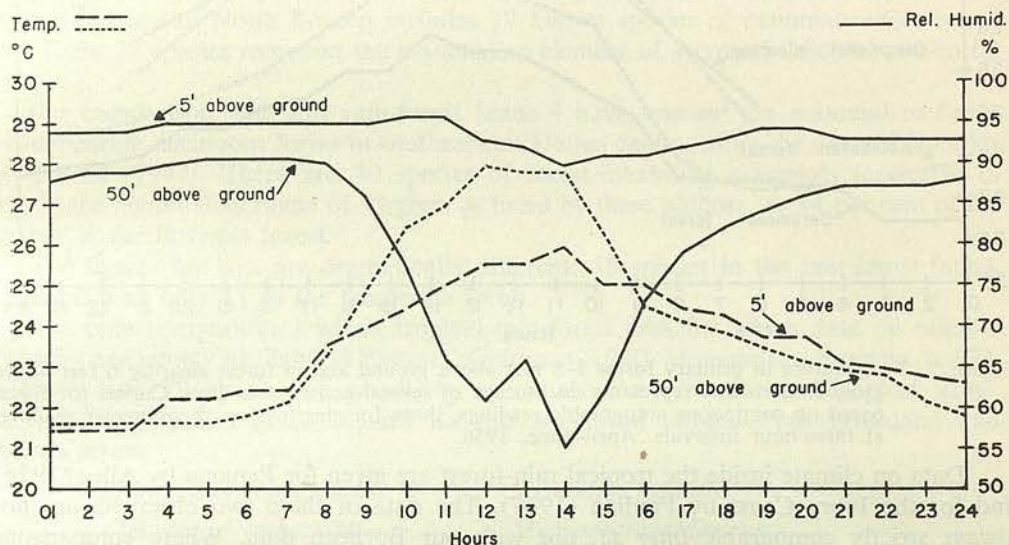


Figure 6. Temperature and humidity relations in primary forest at Deramakot, North Borneo. Each line represents an average of three consecutive days. Data from Bristol Thermohumidigraph charts. April 25–May 1, 1956.

Temperature.—The mean annual temperature at Sandakan for the years 1951–1954 was 26.9°C (80.6°F), with a mean total variation of monthly mean temperature during the year of 2.9°F. The corresponding figures for Jesselton are 26.8° and 3.2°F. Percentage of possible sunshine during the years 1953–1954 was 56 at Sandakan and 57 at Jesselton.

Diurnal temperature variation inside the rain-forest at Deramakot is shown graphically in fig. 6. In the lower story of the forest the mean diurnal range was 4.4°C; at fifty feet, in the middle story, 6.3°C. The difference between the stories is most pronounced during the middle hours of the day; at noon the middle story averaged 4° warmer than the lower story.

Comparative temperatures near ground level in primary forest and adjoining clearing at Deramakot and Kalabakan are shown in fig. 7. Daytime temperatures run consistently higher in the clearings, and have a greater range of diurnal variation than in

the forest. The maximum difference, at noon, was about 10°F. At Deramakot the day-time clearing temperatures were also consistently higher and had a greater range than 50 feet above ground in the adjacent forest; the maximum difference, at noon, was about 6°F.

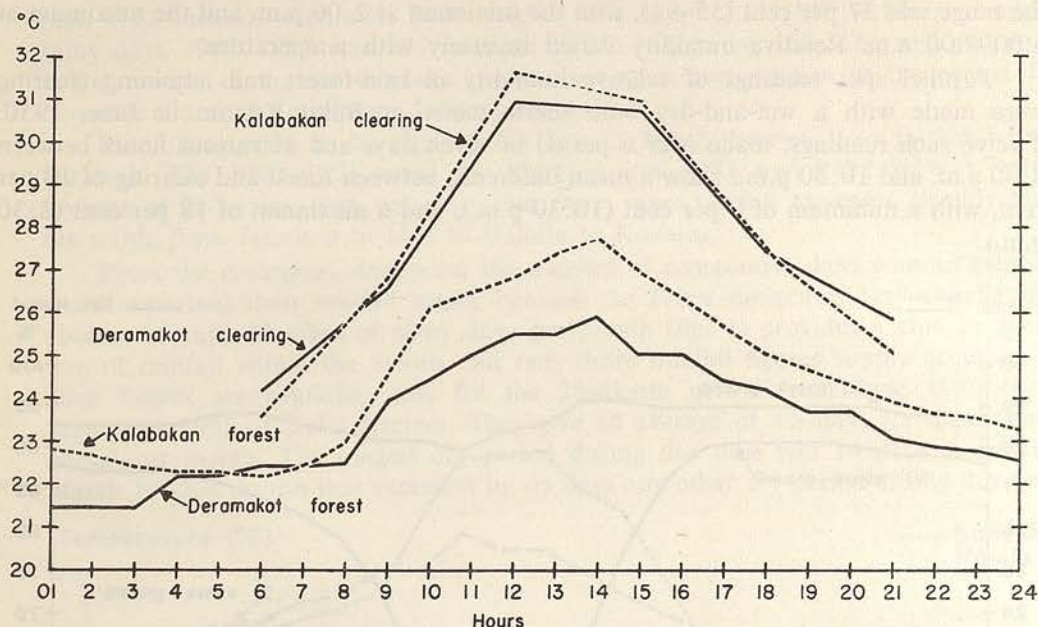


Figure 7. Temperature in primary forest 5-6 feet above ground and in forest clearing 6 feet above ground. Each line represents an average of several consecutive days. Curves for forest based on continuous autographic readings, those for clearings on thermometer readings at three-hour intervals. April-June, 1956.

Data on climate inside the tropical rain-forest are given for Panama by Allee (1926) and for the Ivory Coast by Paulian (1947). The data of these two observers are not always strictly comparable *inter se*, nor with our Bornean data. Where comparisons can be made, agreement among the Neotropical, Ethiopian, and Oriental rain-forests is astonishingly close. Mean diurnal temperature at approximately the same height above ground varies slightly, but the pattern of the daily temperature cycle and the daily range within the cycle are very similar. Data are much more fragmentary for relative humidity, but here too the patterns and ranges at similar levels above ground appear to agree closely.

THE NIPA-MANGROVE ASSOCIATION

The only important lowland formation besides the dipterocarp forest is the nipa-mangrove association, which occupies the tidal lowlands and fringes the coastal rivers as far upstream as the banks are inundated at high tide (Plate 5). In sharp contrast to the adjacent dipterocarp forest, the nipa-mangrove forest is gregarious. It is composed chiefly of nipa palm (*Nipa fruticans*); and mangroves representing several families (*Rhizophora*, *Avicennia*, *Sonneratia*, *Bruguiera*, *Carapa*), all of similar habit. Pure stands of nipa may cover acres, or even square miles as for example along the Trusan Kinabatangan. On the landward side the transition from nipa-mangrove to dipterocarp forest is abrupt; this is especially evident from the air (Plate 2).

The face of the mangrove forest presents a continuous wall of vegetation down to the high-water line, but within the forest it is relatively open, with a dense leafy canopy overhead. Stands of the trunkless nipa palm are difficult to penetrate because of the treacherous footing.

The periodic flooding of this zone by tidal movements creates a habitat unfavorable to mammals, but several species are more or less intimately associated with the nipa-mangrove formation. The proboscis monkey (*Nasalis*) and the crab-eating macaque (*Macacus irus*) are characteristic of this zone. Colonies of flying foxes usually roost in nipa, moving into the dipertocarp forest at dusk to feed. Carnivores are known to enter nipa in search of prey, and nipa is an element in the diet of the elephant.

GENERAL ECOLOGY OF RAIN-FOREST MAMMALS

Relative numbers of species.—The fauna of the lowland rain-forest in the East Coast Residency of North Borneo includes 77 known species of mammals exclusive of bats. These 77 species represent the mammalian element of a typical Oriental rain-forest biotope.

For comparison with this rain-forest fauna I have selected the mammalian fauna of a temperate deciduous forest in southeastern United States, using the data of Handley and Patton (1947). There are 40 species of forest-inhabiting mammals (exclusive of bats) in the mammalian fauna of Virginia as listed by these authors, or 54 per cent of the number in the Bornean forest.

The figures for bats are dramatically different: 58 species in the rain-forest fauna, compared with only 11 in the temperate forest.

The only comparable lowland tropical rain-forest area for which data on number of species are readily available is Panama (Goldman, 1920, *Mammals of Panama*, p. 27). Goldman lists 79 species of non-flying mammals from the Lower Tropical Zone. The following species in Goldman's list are not forest animals, but brushland and savanna forms:

<i>Odocoileus chiriquensis</i>	<i>Sigmodon hispidus</i>
<i>Odocoileus rothschildi</i>	<i>Macrogeomys dariensis</i>
<i>Zygodontomys cherrei</i>	<i>Macrogeomys pansa</i>
<i>Zygodontomys seorsus</i>	<i>Liomys adspersus</i>

Eliminating these 8 species leaves a total of 71, a number that is astonishingly close to the 77 species recorded from the North Bornean rain-forest.

Occupation of habitat zones.—Comparison of the rain-forest fauna with the temperate forest fauna reveals notable differences in distribution among the major habitat zones of the forest, as is shown in the following tabulation.

		Tropical Rain-forest		Temperate Forest	
		No. of species	% of total	No. of species	% of total
Terrestrial	...	40	52	29	72
Arboreal	...	35	45	6	15
Fossorial	...	0	0	2	5
Aquatic	...	2	3	3	8
		77	100	40	100

The most conspicuous difference here is the much more extensive occupation of the arboreal zone in the rain-forest, with a corresponding reduction in number of terrestrial species. This is accounted for only in part by the absence of primates in the temperate forest. The primates represent 13 per cent of the total Bornean species, but even if they are omitted more than 30 per cent of the remaining mammalian fauna is arboreal.

Diurnality vs. nocturnality.—Further comparison of these two faunas with respect to times of daily activity of mammals is shown in the following tabulation. Data for temperate forest mammals are taken largely from Hamilton (1943, *The Mammals of Eastern United States*).

		Tropical Rain-forest		Temperate Forest	
		No. of species	% of total	No. of species	% of total
Diurnal	...	23	30	5	12.5
Nocturnal	...	37	48	19	47.5
Both	...	17	22	16	40
		77	100	40	100

These figures indicate a more even ratio between diurnal and nocturnal forms in the rain-forest than in the temperate forest. Our observations also indicate a sharper division into diurnal and nocturnal groups in the tropics, with fewer species that do not show a pronounced daily rhythm. In the tabulation above, the diurnal component of the tropical forest fauna is accounted for entirely by treeshrews, primates, and squirrels, all obligatory diurnal animals. All of these except two species of treeshrews and one terrestrial squirrel are arboreal animals. The nocturnal component of the tropical forest fauna is made up largely of obligatory or near-obligatory nocturnal forms: 20 of the 36 species are cats, civets, flying squirrels, and other forms such as *Tarsius* and *Nycticebus*, that are strongly adapted morphologically for nocturnalism. In contrast, only 4 or 5 species in the temperate forest fauna show comparable morphological adaptations for nocturnalism. In the tropical forest all individuals of *Rattus* observed by us were seen at night, and all trapped specimens were taken at night, and I have therefore listed all *Rattus* as nocturnal.

Park (1940) made a similar comparison of the mammalian faunas of the Chicago area and the Panama rain-forest, dividing the faunas only into the two components "diurnal" and "nocturnal." After eliminating the bats to make his data comparable with mine, I find his percentages are: *tropical rain-forest*, diurnal, 40 per cent, nocturnal 60 per cent; *temperate forest*, diurnal 46 per cent, nocturnal 54 per cent. These figures differ widely from mine, for both tropical and temperate forest, and Park's statement that "the general ratio of nocturnal to diurnal species is constant for two widely different geographic areas" is not supported by my data.

Diet.—How do the food habits of the tropical and temperate forest mammals compare? In the following tabulation the data for American mammals are taken from the summaries in Hamilton (*loc. cit.*) and Burt (1946, *The Mammals of Michigan*). Data for Bornean mammals are largely our own.

Tropical Rain-forest				Temperate Forest	
	No. of species	% of total		No. of species	% of total
Twigs, leaves, buds ...	15	20		8	20
Fruits and nuts ...	6	8		3	7.5
Mixed fruits, nuts, leaves, buds ...	2	3		2	5
Mixed plant and invertebrate ...	14	18		5	12
Arthropods and other invertebrates ...	10	13		7	17.5
Termites ...	1	1		0	0
Mixed invertebrate and vertebrate	4	5		2	5
Vertebrate ...	7	9		6	15
Omnivorous ...	11	14		7	17.5
Unknown ...	7	9		—	—
	77	100		40	99.5

Agreement between the mammalian faunas of the tropical and temperate forests in major dietary habits appears to be astonishingly close. There is no category, except the very specialized one of termite-feeding, in which the percentages seem to differ significantly.

A few tentative generalizations may be made on relations between diet and the ecology and morphology of Bornean mammals. Differentiation in food habits among closely-related forms is clearly evident in instances where enough data are available. This is notably true among the squirrels (p. 73) and treeshrews (p. 45), less evident, perhaps because of insufficient data, for the civets (p. 103). The treeshrew situation is further interesting because the diurnal *Tupaia tana* (a treeshrew) and the nocturnal *Echinosorex* (an erinaceid insectivore) seem to be exploiting the same food niche on a "double shift" basis, whereas the two terrestrial treeshrews, *Tupaia tana* and *T. glis*, both diurnal, operate in different food niches. Orthopteroids² form a disproportionately large fraction of the insects entering the diets of many insect-eating mammals. They were heavily predominant in the stomachs of *Tarsius* and the civets, less so for treeshrews, and still less so for *Echinosorex*. Orthopteroids were scarcely represented, by contrast, in stomachs of the heavily insectivorous squirrel *Sundasciurus lowi*, the only insect-eating rodent for which we have data. Often there is little or no correlation between dentition and diet among closely-related mammals. Among the squirrels, for example, there appears to be wide variation in diet from species to species, with little associated variation in the dentition (p. 73). The civets, on the other hand, exhibit a wide range of variation in both dentition and diet, but these are correlated in only the most general way (p. 102).

2. Orthoptera *sensu lato*, including also Phasmidae, Mantidae, and Blattidae.

A notable correlation is the tendency for mammals that include a significant proportion of earthworms in their diet to have the snout attenuated. This is evident in *Echinosorex*, *Tupaia tana*, and *Hemigalus derbyanus*. It is interesting that the rostral region is elongated in *Rattus manipulus* of Assam and Burma, a species in which according to Roonwal (1949, *Trans. Nat. Inst. Sci. India*, 3: 102) earthworms form a large proportion of the diet.

Breeding season.—All adult female mammals, except bats, collected by the Bornean Zoological Expeditions 1950 and 1956 were examined for pregnancy and lactation. Data on 201 adult females collected between April 9 and August 15 were recorded. Of these, 51 were pregnant. These data were studied by Wade (1958). She divided the mammals into two groups: those with a gestation period greatly exceeding 60 days, and those with a gestation period of 60 days or less. In both groups the onset of breeding coincided with the period of minimum rainfall, the pregnancy rate reaching a maximum in July and August. For the collection as a whole, the pregnancy rate rose steadily from 0 in April to 44 per cent of all adult females in August. The picture between the middle of August and the end of March, which includes the period of maximum rainfall, is of course unknown because we were not in the field during that period.

Harrison (1952, 1955) concluded that there is no breeding season among rodents and insectivores in Malaya, but only irregular fluctuations in pregnancy rate that are broadly related to amount of rainfall in any given month.

We may conclude from the preceding data that the Bornean rain-forest supports almost twice as many species of mammals as a temperate forest, that the percentage of arboreal species is notably greater in the tropical forest, and that the proportion of strictly diurnal species is much greater with fewer species not showing a pronounced daily activity rhythm. Despite wide disparity in the taxonomic composition of the two faunas, the proportion of each that falls into each of the several dietary categories is very similar. There appears to be a breeding season in the Bornean fauna, but it is correlated with rainfall, and not with day length as in the temperate forest.

ZOOGEOGRAPHY OF NORTH BORNEO

A good, though brief, account of the zoogeography of Bornean mammals was given by Chasen (1940: xiii–xiv). My conclusions agree substantially with his.

There is evidence of at least two poorly-defined faunal areas in the lowlands of North Borneo. These two regions appear to be separated by the north-south mountain ranges lying south of Mt. Kinabalu. Region 1 is much the larger. It embraces the area east of a line drawn south from Marudu Bay, and includes the basins of the Sugut, Labuk, Kinabatangan, and Segama rivers. Region 2 is the area west of this line, which includes the basins of several short rivers flowing west into the South China Sea. Region 2 continues southward into Sarawak for an unknown distance; the Baram River seems to mark an approximate southern boundary.

Five species of mammals are represented in Regions 1 and 2 by forms distinct enough to be given subspecific status. These are: *Echinosorex gymnurus*, *Tupaia minor*, *Presbytis*

hosei, *Callosciurus prevosti*, and *Sundasciurus hippurus*. In three of these the coloration is paler in the eastern region than in the western, in one (*Callosciurus prevosti*) it is darker, and the fifth (*Presbytis hosei*) is distinguished by head coloration.

There is some indication that North Bornean mammals tend to be slightly dwarfed compared with their counterparts farther south, and that southern Philippine forms in turn tend to be smaller than those of North Borneo.

In only five instances do we have adequate population samples of the same species from North Borneo and from a more southern Bornean locality. In four of these (*Tupaia tana*, *Callosciurus notatus*, *Sundasciurus hippurus* and *Rattus mulleri*), skull measurements of the North Bornean form are slightly but significantly smaller than skull measurements of the same species from Kuching, Sarawak. In the fifth species (*Tragulus javanicus*), on the contrary, the North Bornean form is distinctly larger than its counterpart in Indonesian Borneo (p. 122).

Adequate samples for comparing North Bornean with southern Philippine forms are at hand for four species. In three of these the Philippine representative is smaller in skull dimensions: *Tupaia glis* > *Tupaia palawanensis*, *Tarsius bancanus* > *Tarsius syrichta*, *Mydaus javanensis* > *Mydaus marchei*. In the fourth (*Paradoxurus hermaphroditus*) the Philippine representative is larger (p. 100).

Endemism.—The Bornean mammalian fauna is more specialized than anywhere else in the Malaysian subregion. Borneo has four (perhaps five) endemic genera of mammals, all monotypic. Two of these (*Nasalis* and *Rheithrosciurus*) are very distinctive. *Nasalis* is related to the snub-nosed monkeys of western China, Tonkin, and the Mentawi Islands, and thus appears to be a relict. The relationships of *Rheithrosciurus* are unknown; Moore (1961) believed the presence of two septa in the auditory bulla and of four pairs of mammae ally it to the Holarctic *Sciurus*, but much more evidence is needed before so improbable a relationship can be accepted. Both *Nasalis* and *Rheithrosciurus* are lowland forms.

The three remaining genera (*Paralariscus*, *Glyphotes*, and *Diplogale*) represent a quite different situation. Each differs only slightly from a common and more widely distributed genus. *Glyphotes* and *Diplogale* are montane forms. These three genera may have differentiated in Borneo.

Too little is known of the inter-relationships among species in the Malaysian subregion to permit generalization. Species have been described from each of the larger land masses, but there has been little attempt to synthesize these analytical data. Careful comparison of the North Bornean with the Philippine fauna is extremely desirable but has been hampered by political factors. Students and collections of the Philippine fauna have been chiefly American, of the Malaysian fauna chiefly British and Dutch, and the artificial political boundaries have tended to act as barriers to zoological thinking.

SYSTEMATIC ACCOUNT OF THE MAMMALS OF NORTH BORNEO

A total of 144 forms, representing 135 species, is recognized in the following account. Of these, 60 forms representing 58 species are bats, leaving a total of 84 forms and 77 species of non-flying mammals in the North Bornean fauna.

The distribution of species and subspecies among the various orders is shown in the following table. Four of the ten orders account for 90 per cent of the species.

			Number of species	Number of species and subspecies
Insectivora	...	...	3	4
Dermoptera	...	...	1	1
Chiroptera	...	...	58	60
Primates	...	...	16	21
Pholidota	...	...	1	1
Rodentia	...	...	28	29
Carnivora	...	...	20	20
Proboscidea	...	...	1	1
Perissodactyla	...	...	1	1
Artiodactyla	...	...	6	6
			<hr/> 135	<hr/> 144

INSECTIVORA

The insectivores are represented in Borneo only by the gymnures and shrews. Moles (Talpidae) occur in the Malay Peninsula, but are not found in any of the East Indian islands.

GYMNURES

Family ERINACEIDAE, Subfamily ECHINOSORICINAE

This group contains some of the most primitive and generalized of living placental mammals. Only *Echinosorex* is found in the lowland forest. The short-tailed lesser gymnure (*Hylomys*) is present on Mt. Kinabalu above 3,000 feet.

***Echinosorex gymnurus albus* Giebel.** Gymnure or Moon Rat, *Ticus bulan*. (Plates 6, 7).

Gymnura alba Giebel, 1863, Zeitschr. Ges. Nat., 22: 277.—Banjermasin, South Borneo.

Echinosorex gymnurus albus Chasen, 1934, Bull. Raffles Mus., 9: 87.—suggests Banjermasin as type locality.

General appearance rat-like, with a long scaly naked tail and a long pointed muzzle. Pelage white above and below, with a few scattered black-tipped hairs on the dorsal surface; the black-tipped hairs may tend to form a patch on the nape. Nose and ears pink. Tail white throughout.

Mean and extreme head and body lengths of 8 adult specimens from the Sapagaya Forest Reserve 366 (335–396); tail 248 (207–292); hind foot 69.5 (68–75). Mean and extreme measurements of six skulls are: greatest length 87.8 (85.5–90.5), condylobasal length 87.6 ± 1.09 (85.3–90.5), zygomatic breadth 43.3 (41.8–45), palatal length 53.4 (51.4–55), upper tooth row, including all teeth, $48.0 \pm .39$ (46.5–48.9). All these measurements, both flesh and skull, run somewhat higher than those given by Chasen and Kloss (1931) for seven specimens from Bettotan.

Females appear to be slightly heavier than males; three adult females (non-gravid) weighed 1,075, 1,075, and 1,100 grams, four males 870, 1,025, 1,025, and 1,050 grams.

This animal is widely distributed over Borneo, in both primary and secondary forest and in cultivated areas, but is locally spotty. We saw only one individual in two months of field work at Dewhurst Bay, but collected ten and observed several others in one month in the Sapagaya Forest Reserve. It is strictly nocturnal and terrestrial.

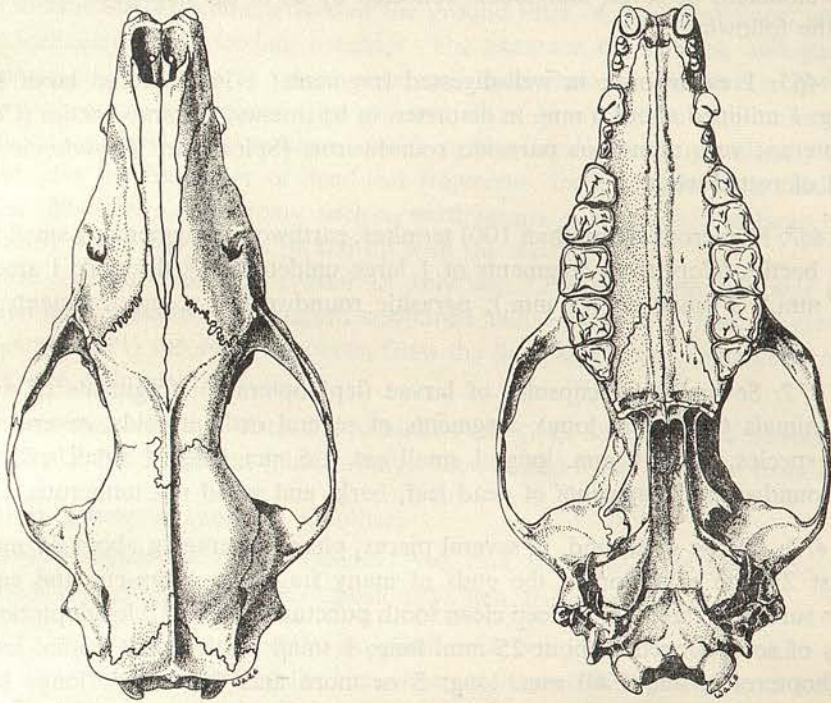


Figure 8. Skull of *Echinorex gymnurus albus*. CNHM no. 68740, adult ♂, Sapagaya Forest Reserve. X 1.

A captive individual was kept under observation for several days at Bukit Kretam. Its reactions were very slow, with a general lack of alertness; appearance and behavior were astonishingly reminiscent of the American opossum (*Didelphis*). When approached, its reaction was to open the mouth slightly and produce a very low moaning sound. If an object was brought within range of its jaws, the animal turned with surprising speed and bit savagely; these movements contrasted sharply with its slow and stupid-appearing reactions under other circumstances. This individual refused all food.

Echinorex walks with a rat-like gait, the body held well clear of the ground. The hind foot, which has an elongated tarsus, is digitigrade, the heel being held well clear of the ground in an almost artiodactyl posture. When pressed, the animal breaks into a clumsy rocking gallop. It is easily overtaken by a man on foot.

This species has a very definite and distinctive ammoniacal odor, which is apparent at a distance of several yards. It has none of the musky quality that is associated with the scent of shrews or with mustelids or civets.

Banks states that in captivity the gymnure "is fond of frogs and fish (cockroaches too)", and Harrison (1950) wrote of the Malayan *E. g. gymnurus* that "in my experience they are usually trapped near streams, and from observations on a captive specimen I believe that they usually feed on fish. Presented with a shallow trough of water in which small fish were swimming it would immediately take to paddling and catching the fish in its long narrow jaws with an ease which I envied."

The stomachs of seven individuals collected by us in the Sapagaya Forest Reserve yielded the following:

No. 465: 1 earthworm, in well-digested fragments; 1 lepidopteran larva about 17 mm. long; 1 milliped about 6 mm. in diameter, in fragments; 2 scarab beetles (Coprinae); 1 orthopteran; very numerous parasitic roundworms (Spiruridae: *Physaloptera* sp.); 1 fragment of rotted wood.

No. 467: Numerous (more than 100) termites; earthworm fragments; 1 small milliped; 2 scarab beetles (Coprinae); fragments of 1 large unidentified arthropod; 1 small insect larva (3 mm.); 1 small ant (3 mm.); parasitic roundworms; a few fragments of dead leaves.

No. 472: Several head capsules of larvae (lepidopteran?); fragments of numerous beetles (animals 6–25 mm. long); fragments of several orthopteroids; several ants, all the same species, about 6 mm. long; 1 small ant, 1.5 mm. long; 1 small spider; a few parasitic roundworms; fragments of dead leaf, bark, and wood not numerous.

No. 473: 1 large gastropod, in several pieces; pieces (averaging about 25 mm. long) of at least 2 large earthworms, the ends of many fragments clean-cut and each with numerous surface scratches and deep clean tooth punctures; about 10 lepidopteran larvae; fragments of several beetles about 25 mm. long; 1 small beetle about 2 mm. long; 2 or more orthopteroids, about 40 mm. long; 5 or more ants 2–12 mm. long; 1 spider; numerous parasitic roundworms; several fragments of dead leaf, many of rotted wood.

No. 499: 1 lepidopteran larva about 15 mm. long, not fragmented; remnants of 6 or more beetles 10–25 mm. long; 1 beetle larva about 20 mm. long; fragments of about 4 orthopteroids; a few minute arthropods (less than 2 mm.), of which at least 6 are mites and 1 a small ant; 20 or more ants of two species, each about 12 mm., several sharply cut in half; miscellaneous unidentified arthropod fragments; several unidentified masses of animal protein about 5 mm. in diameter (probably earthworm); parasitic roundworms; a few small fragments of dead leaves and rotten wood.

No. 505: pieces (averaging about 25 mm. long) of large earthworm, ends of many fragments clean-cut and each with numerous deep clean tooth punctures; numerous arthropod fragments (ants, beetles, orthopteroids, small flies), many representing individuals 2–3 mm. long, others up to 50 mm.; 1 spider; 1 pseudoscorpion; numerous parasitic roundworms; many fragments of dead leaves and rotted wood.

No. 511: 1 unidentified fruit, almost whole, about 15 mm. long; 12–15 fruit stems, similar to preceding, and additional fruit parts; 1 lepidopteran larva about 25 mm. long;

large mass of well-chewed arthropod fragments, including 3 or more orthopteroids (40–50 mm.), 2 minute ants (1.5–2 mm.), 2 spiders, and 1 small mite; a few parasitic roundworms; numerous fragments of dead leaves and a few fragments of rotten wood.

These seven samples indicate that *Echinosorex* feeds almost exclusively on earthworms and arthropods. Earthworms account for more than half the total bulk. Fruit, no doubt picked up from the forest floor, was present in one stomach, which proves that the gymnure is not exclusively carnivorous.

The food items are characteristic of the ground litter of the forest floor, and permit certain conclusions as to feeding behavior. The presence of termites, and particularly the frequency of fragments of rotted wood and dead leaves, indicate that *Echinosorex* scratches and/or roots in rotted logs and leaf litter. Many of the prey animals are so minute that they could scarcely have been recognized and picked up individually. Their small size, plus the frequency of dead-leaf fragments, indicate that some feeding is by licking the substrate. Larger items, such as earthworms, gastropods, and large beetles or orthopterans, would have to be picked up with the teeth.

Of five females collected between 14 July and 12 August only one was pregnant. This individual, collected 12 August, contained two embryos 71 mm. in crown-rump length. Lyon (1911) records a specimen from the Sempang River, southwestern Borneo, with only one embryo.

Specimens examined.—Total 15. Sandakan mi. 8 (4), Sapagaya Forest Reserve (10), Deramakot (1), Bukit Kretam (photos only). Chasen and Kloss record it from Bettotan.

Echinosorex gymnurus candidus Günther.

Gymnura rafflesii var. *candida* Günther, Proc. Zool. Soc. London, 1876, p. 425.—Labuan.

Echinosorex gymnurus candidus Chasen, 1934, Bull. Raffles Mus., 9, p. 87.

On Labuan and the opposite mainland and on down the west coast as far as Kuching, the white gymnure of the remainder of Borneo is replaced by a form that is pied black and white or is plentifully sprinkled with long black hairs on the upper parts.

I have seen no specimens of this form from North Borneo.

SHREWS

Family SORICIDAE

Shrews appear to be singularly uncommon in North Borneo, except at high altitudes on Mt. Kinabalu. So few specimens are known of the lowland forms that identification must be regarded as provisional. Two genera have been recorded from North Borneo: *Crociodura*, which has three unicuspid teeth in the upper jaw, and *Suncus* which has four.

Crociodura doriae Peters.

Gray Shrew.

Crociodura doriae Peters, Monatsber. K. Akad. Wiss. Berlin, 1870, p. 587.—Sarawak.

A small mouse-like mammal with a sharp pointed muzzle, small but prominent ears, and a stout tapering tail covered with scattered bristles. The tail is more than half the length of the head and body. Color uniform brownish gray above, dark gray

below. Vibrissae white-tipped. Measurements of an adult female from Sandakan are: total length 157, tail 67, hind foot 18; total skull length 24.6, basal length 22.5, palatal length 12, upper tooth row 11.4.

This specimen, collected by F. C. Wonder on the Crane Pacific Expedition, is the only representative of *Crocidura* known from the lowlands of North Borneo. The Asiatic Primate Expedition got 19 specimens on Kinabalu between 3,000 and 11,000 feet. The Sandakan specimen has more cinnamon in the coloration than does one specimen from the Asiatic Primate Expedition series that is available for comparison. The latter expedition collected *Crocidura baluensis* Thomas on Kinabalu between altitudes of 9,000 and 12,000 feet, and a single specimen of *Crocidura foetida* Peters at Lumu Lumu (5,500 feet) on Kinabalu.

Specimens examined.—Sandakan mi. 8 (1).

***Suncus murinus murinus* Linnaeus.**

Musky Shrew.

Sorex murinus Linnaeus, 1766, Syst. Nat., 12th ed., 1: 74.—Java.

Sorex caeruleus Kerr, 1792, Animal Kingdom, p. 207.—Java.

A single specimen of this shrew is recorded (as *Suncus caeruleus*) from Victoria, Labuan, by Allen and Coolidge, who state that it may have been introduced. We have a second specimen, also from Labuan.

Suncus hosei Thomas was described from the Bakong River, Baram, Sarawak, but has not been recorded from North Borneo.

Specimens examined.—Labuan (1).

DERMOPTERA

Family GALEOPITHECIDAE

Two species of this remarkable mammal are known: *Galeopithecus*³ *volans* from the Philippines and *Galeopithecus variegatus* from the Malaysian subregion, Siam, and Indochina. The two species are strikingly different in many cranial and dental features, and *G. variegatus* is often regarded as a distinct genus, *Galeopterus*. Such cleavage serves no useful purpose; it produces two monotypic genera, and I feel overemphasizes the distinctness of two well-marked species. The Philippine *volans* is clearly more primitive than *variegatus*, in which the teeth are much reduced and specialized. Reduction is particularly evident in the lateral upper incisor and the upper canine (fig. 9). The differences in dentition between *volans* and *variegatus* suggest that the feeding habits may not be the same. In both species the shearing occlusion of incisors and canines is remarkable.

Chasen (1940) referred all Bornean flying lemurs to the subspecies *natunae*.

3. The International Commission refused to validate the name *Galeopithecus* (Opinion 90), which makes *Cynocephalus* the technically correct name, and the family name Cynocephalidae. I do not feel bound by this dereliction, because the confusion produced by such name shifting more than outweighs the much over-rated advantages of blind conformity to nomenclatural rules.

***Galeopithecus variegatus natunae* Miller.**

Flying Lemur. (Plate 8)

Galeopithecus natunae Miller, 1903, Smiths. Misc. Coll., 45: 50.—Bunguran Island.*Galeopterus variegatus natunae* Chasen, 1940, Bull. Raffles Mus., 15: 21.*Galeopterus borneanus* Lyon, 1911, Proc. U.S. Nat. Mus., 40: 124.—Tjantung, near Klumpang Bay, Southeast Borneo.

The form of the flying lemur is so distinctive that a description is scarcely needed. Coloration is extremely variable. In Borneo, as in other parts of the range, there are two color phases. The usual color is gray, often vermiculated with black and with scattered white spots. Less common is a brown or reddish coloration. Both of our specimens represent the gray phase, although the female is much paler than the male; in both a broad band of olivaceous extends the entire length of the neck and body on either side of the dorsal midline. The underside of both individuals is brown.

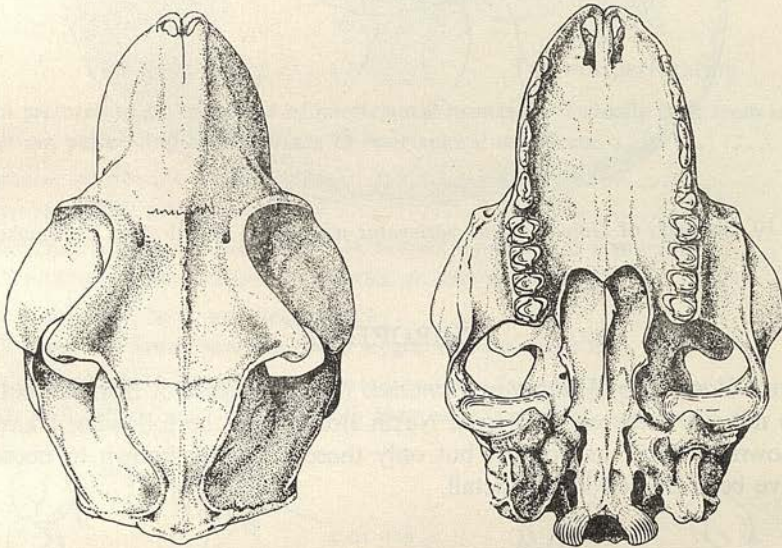


Figure 9. Skull of *Galeopithecus variegatus natunae*. CNHM no. 68785, adult ♀, Bukit Kretam. X 1.

Measurements of these two specimens are: Total length 620, 585; tail 245, 241; hind foot 65, 73. Greatest skull length 68.4, 68.1; condylobasal length 68, 65.5; palatal length 33, 32.5; bi-orbital breadth 46, —; interorbital constriction 16.7, 18; upper tooththrow 31.4, 31.9. Weights of these individuals were 1,300 and 925 grams, the male being the smaller. Chasen and Kloss (1929) pointed out that the Bornean race of *variegatus* is the smallest on the larger land-masses of the Oriental Region.

Flying lemurs are entirely arboreal and strictly confined to the forest. They are crepuscular and nocturnal in habits. One of our specimens, a female, was clinging head upward on the trunk of a large tree at the edge of a clearing at 6:30 p.m. Another was taken in primary forest, gliding about 90 feet above ground, in mid-morning. The female was carrying a single young less than half grown (June 30), which clung tenaciously to her. The young are normally carried in a hammock formed by the parachute of the suspended mother (Plate 8). The young emitted a series of duck-like quackings, and according to Banks the cry of the adult is similar but rarely used.

Specimens examined.—Bukit Kretam (1 female and young), Deramakot (1). Chasen and Kloss record it from Bettotan and Banguay Island.

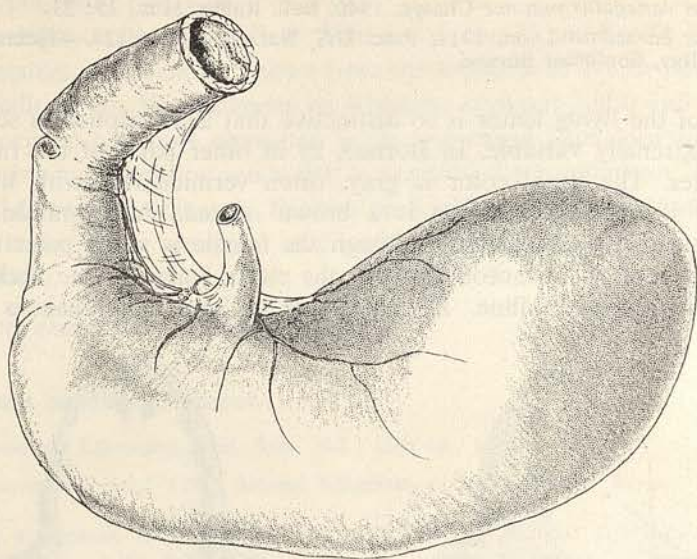


Figure 10. Stomach of *Galeopithecus variegatus natunae* in dorsal view. Deramakot. X 1.

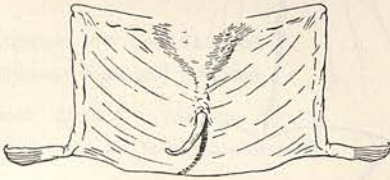
CHIROPTERA

Chasen's *Handlist of Malaysian Mammals* lists 61 species of Bornean bats. Many of these have not yet been reported from North Borneo. In the following I have listed all species known to occur in Borneo, but only those presently known to occur in North Borneo have been treated in any detail.

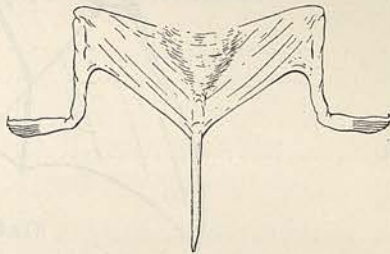
KEY TO GENERA OF BORNEAN BATS

- | | | |
|------|--|----------------------|
| 1 a. | First and second fingers of wing both provided with claws | 2 |
| b. | First finger (thumb) only with a claw | 10 |
| 2 a. | Size large, forearm more than 180 mm. (7 inches) | <i>Pteropus</i> |
| b. | Size smaller, forearm less than 90 mm. (3½ inches) | 3 |
| 3 a. | Forearm more than 70 | 4 |
| b. | Forearm less than 70 | 5 |
| 4 a. | Cheek teeth $\frac{5}{5}$ (first upper premolar minute) | <i>Rousettus</i> |
| b. | Cheek teeth $\frac{3}{3}$ | <i>Dyacopterus</i> |
| 5 a. | Incisors $\frac{1}{1}$, no tail | 6 |
| b. | Incisors $\frac{2}{2}$ or $\frac{3}{3}$, tail present or absent | 7 |
| 6 a. | Cheek teeth $\frac{4}{4}$, forearm about 55 | <i>Megaerops</i> |
| b. | Cheek teeth $\frac{5}{5}$, forearm about 40 | <i>Balionycteris</i> |
| 7 a. | Incisors $\frac{1}{1}$ | 8 |
| b. | Incisors $\frac{2}{2}$ | 9 |

- 8 a. Forearm about 60, tail present *Penthetor*
 b. Forearm about 45, no tail *Aethalops*
 9 a. Forearm 60–70, a short tail present *Cynopterus*
 b. Forearm about 40, no tail *Macroglossus*
 10 a. No visible tail (interfemoral membrane extensive) *Megaderma*
 b. A visible tail, wholly or partly enclosed in interfemoral membrane 11

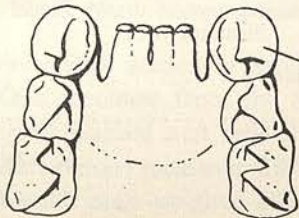


Tail perforating

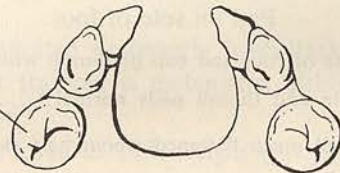


Tail not perforating

- 11 a. Tail perforating upper surface of interfemoral membrane distinctly back from its edge .. 12
 b. Tail not perforating upper surface of interfemoral membrane 13
 12 a. Forearm 40–50; two upper incisors *Emballonura*
 b. Forearm 55–65; one upper incisor *Taphozous*
 13 a. More than half of tail projecting free beyond interfemoral membrane 14
 b. Tail enclosed in interfemoral membrane, or only tip projecting 16
 14 a. Tail nearly half head and body length 15
 b. Tail about one fourth head and body length; forearm more than 70 *Eonycteris*
 15 a. Upper surface of body almost completely hairless; forearm 75–80 *Cheiromeles*
 b. Body well haired; upper lip thick, with deep vertical wrinkles, forearm 40–50 *Tadarida*

Premaxillary bones
meeting at midline

canine

Premaxillary bones
not meeting at midline

- 16 a. Tail longer than head and body; premaxillary bones meeting at midline *Nycteris*
 b. Tail shorter than head and body; premaxillary bones not meeting at midline 17

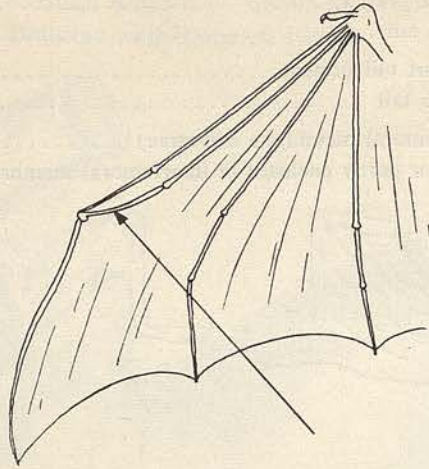


Nostrils tubular



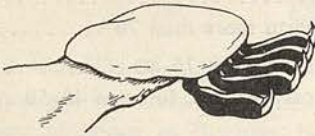
Nostrils normal

- 17 a. Nostrils in the form of two diverging tubes, opening laterally; forearm about 35 .. *Murina*
 b. Nostrils normal, not in the form of two diverging tubes 18



First phalanx of third finger short

- 18 a. First phalanx of third (longest) finger very short, less than $\frac{1}{3}$ length of terminal phalanx *Miniopterus*
 b. First phalanx of third finger longer than terminal phalanx 19
 19 a. Fifth finger short, about as long as metacarpal of third or fourth digits *Nyctalus*
 b. Fifth finger longer than metacarpals three or four 20

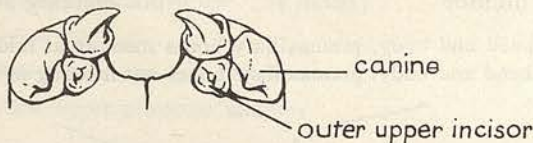


Pad on sole of foot



Normal foot

- 20 a. Sole of foot and ball of thumb with well developed pads 21
 b. Sole and thumb pads normal 22
 21 a. Skull much flattened, about half as high as wide *Tyloncteris*
 b. Skull not flattened, more than half as high as wide *Glischropus*

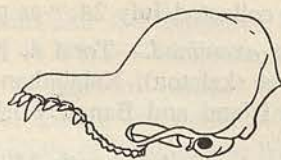


Outer upper incisor displaced

- 22 a. Outer upper incisor small and displaced backward from toothrow *Hesperoptenus*
 b. Outer upper incisor normal 23
 23 a. Cheek teeth $\frac{6}{6}$ 24
 b. Cheek teeth less than $\frac{6}{6}$ 25



Myotis



Kerivoula

- 24 a. Braincase low and flattened *Myotis*
 b. Braincase high and rounded *Kerivoula*
- 25 a. Cheek teeth $\frac{5}{5}$; forearm 30–38 *Pipistrellus*
 b. Cheek teeth $\frac{4}{4}$; forearm about 50 *Scotophilus*

FRUIT BATS

Family PTEROPODIDAE

***Rousettus amplexicaudatus amplexicaudatus* E. Geoffroy.**

Pteropus amplexicaudatus E. Geoffroy, 1810, Ann. Mus. Nat. Hist. Paris 15: 96.—Timor.

Rousettus amplexicaudatus amplexicaudatus Chasen, 1931, Bull. Raffles Mus., 5: 110 (Madai Caves).

***Pteropus hypomelanus tomesi* Peters.**

Small Flying Fox.

Pteropus hypomelanus var. *tomesi* Peters, 1868, Monatsber. Akad. Berlin 1868: 626.—Labuan.

***Pteropus vampyrus natunae* Andersen.**

Flying Fox.

Pteropus vampyrus natunae Andersen, 1908, Ann. Mag. Nat. Hist. (8) 2: 369.—Panjang Island, North Natuna Islands.

Mantle reddish golden to chestnut, sharply separated posteriorly from darker color of back. One specimen from the Sapagaya Forest Reserve is melanistic, although the mantle is well marked and reddish brown in color.

An adult female measures 287 in total length, forearm 193, weight (pregnant) 725 grams. An adult male weighed 800 grams. Measurements of three adult skulls: condyl-obasal length 73.2, 71.8, 72.0; zygomatic breadth 40, 41.5, 42.0; palatal length 41, 40.5, 41.6; upper cheek teeth 19.8, 20.0, 18.4.

This is the common flying fox of North Borneo. They are said to roost in the nipa forest during the day and migrate in late afternoon into the forest to feed. Such flights, numbering hundreds of individuals strung out in very loose formation, were observed on the Kretam Besar River in 1950 and at Kalabakan in 1956. On one occasion in the Sapagaya Forest Reserve a great number of flying foxes of this species was discovered at about 10 p.m. feeding in a fruiting tree (*Cryptocarya* sp.: Lauraceae) in the forest. The ground beneath the tree was littered with fallen fruits, and fruits could be heard dropping as we approached the tree. The fruit of this tree is about 25 mm. long, with a thick rind and a pulpy interior. Many of the fruits on the ground had been neatly sliced open and the pulp removed.

A female collected July 24, was pregnant. She contained a single young.

Specimens examined.—Total 4. Narbahan (near Weston) (1), Sapagaya Forest Reserve (2, one a skeleton), Kalabakan (1). Chasen and Kloss record this species from Balambangan Island and Banguey Island.

Cynopterus brachyotis brachyotis Müller. Malaysian Fruit Bat.

Pachysoma brachyotis Müller, 1838, Tijdschr. Nat. Geschied. Physiol., 5, pt. 1, p. 146.—Borneo.

Not yet recorded from North Borneo.

Cynopterus horsfieldi persimilis Andersen. Horsfield's Fruit Bat.

Cynopterus persimilis Andersen, 1912, Ann. Mag. Nat. Hist. (8) 10: 640.—Sarawak.

Not yet recorded from North Borneo.

Megaerops ecaudatus Temminck. Tailless Fruit Bat.

Pachysoma ecaudatus Temminck, 1837, Mon. Mamm., 2, p. 94.—Padang, West Sumatra.

Not yet recorded from North Borneo.

Dyacopterus spadiceus Thomas.

Cynopterus spadiceus Thomas, 1890, Ann. Mag. Nat. Hist. (6) 5: 235.—Baram, Sarawak.

Not yet recorded from North Borneo.

Balionycteris maculata maculata Thomas. Spotted-winged Fruit Bat.

Cynopterus maculatus Thomas, 1893, Ann. Mag. Nat. Hist. (6) 11: 341.—Sarawak.

Balionycteris maculata maculata Chasen, 1931, Bull. Raffles Mus., 5: 110 (Baturong Caves).

Aethalops aequalis Allen.

Aethalops aequalis Allen, 1938, Jour. Mamm. 19: 497.—Mt. Kinabalu, North Borneo, 5,500 ft.

Penthetor lucasi Dobson. Dusky Fruit Bat.

Cynopterus (Ptenochirus) lucasi Dobson, 1880, Ann. Mag. Nat. Hist. (5) 6: 163.—Sarawak.

Penthetor lucasi Andersen, 1912, Cat. Chiroptera Brit. Mus., v.1, p. 669.

Not yet recorded from North Borneo.

Eonycteris spelaea Dobson. Cave Fruit Bat.

Macroglossus spelaeus Dobson, 1871 Proc. Asiatic Soc. Bengal, 1871: 105.—Moulmein, Burma.

Eonycteris spelaea Dobson, 1873, Jour. Asiatic Soc. Bengal 42: 204.

Eonycteris spelaea spelaea Chasen, 1931, Bull. Raffles Mus., 5: 110 (Tapadong Caves).

Macroglossus lagochilus Matschie. Long-tongued Fruit Bat.

Macroglossus lagochilus Matschie, 1899, Megachir., p. 96.—Buru, Moluccas.

Not yet recorded from North Borneo.

Family EMBALLONURIDAE

Emballonura monticola monticola Temminck. Sheath-Tailed Bat.

Emballonura monticola Temminck, 1838, Tijdschr. Nat. Geschied. Physiol. 5: 25.—Java.

Color above seal brown, the hairs much paler at the base. Throat and chin reddish brown.

A series of 12 individuals from Bukit Kretam and the Sapagaya Forest Reserve measures: head and body 42.9 (40–46.5), forearm 44.4 (42.8–46.1). Skull measurements of three of the largest specimens are: condyle to front of canine 12.7, 12.6, 12.5; zygomatic breadth 8.9, 8.3, 8.7; front of canine to rear of last molar 5.4, 5.3, 5.3.

The Sapagaya specimens were found in the hollow of a fallen tree trunk in primary forest. The Bukit Kretam individual was flying along a small stream in primary forest at 10 a.m. Abbott (in Lyon, 1911) records this species from beneath overhanging rocks in forest and from a cave.

Specimens examined.—Bukit Kretam (1), Sapagaya Forest Reserve (1 skin and skull, 12 in alcohol). Chasen and Kloss record this form from Bettotan, and Chasen (1931) from the Tapadong caves near Lahad Datu.

***Emballonura rivalis* Thomas.**

Emballonura monticola rivalis Thomas, 1915, Ann. Mag. Nat. Hist. (8) 15: 140.—Bida, Sarawak.

Emballonura rivalis Chasen, 1931, Bull. Raffles Mus., 5: 113 (Baturong and Tapadong Caves).

The status of this form is uncertain. It was distinguished from *E. m. monticola* on the basis of slightly larger size (forearm 48). Chasen (1931) identified specimens from the Baturong and Tapadong caves as *rivalis* (forearm 47.8 (47–48.5), stating that they occurred side by side with *monticola*. None of our *Emballonura* quite equals the measurements given by Thomas for *rivalis*.

***Taphozous affinis* Dobson.**

White-breasted Bat.

Taphozous affinis Dobson, 1875, Ann. Mag. Nat. Hist. 16: 323.—Labuan.

Saccolaimus affinis Robinson and Kloss, 1918, Jour. Fed. Malay States Mus. 8: 78.—Chasen, 1940, Bull. Raffles Mus., 15: 32.

***Taphozous flavimaculatus* Sody.**

Saccolaimus flavimaculatus Sody, 1931, Nat. Tijdschr. Ned. Ind. 91: 355.—Kutei, East Borneo. —Chasen, 1940, Bull. Raffles Mus., 15: 32.

***Taphozous longimanus albiginnis* Thomas.**

Taphozous longimanus albiginnis Thomas, 1898, Ann. Mag. Nat. Hist. (7) 2: 246.—Labuan.

An old specimen in alcohol, and a male collected at Bongon in January 1893 (probably by A. H. Everett) agree with the description of the type. Forearm 56.5 (56 in the type); skull, condyle to front of canine, 19.3; upper toothrow 8.5.

Specimens examined.—Bongon (1 in alcohol, skull removed).

***Taphozous melanopogon fretensis* Thomas.**

Taphozous melanopogon fretensis Thomas, 1916, Jour. Fed. Malay States Mus. 7: 5.—Terutau Island, Straits of Malacca.—Chasen, 1931, Bull. Raffles Mus., 5: 114 (Baturong and Tapadong Caves, Berhala Island).

General color above (from a specimen from Berhala Island, originally preserved in alcohol and later skinned) is reddish buff. The hairs are almost white throughout most of their length, and are tipped with reddish buff. Belly cream. There is no trace of the black "beard" for which the species was named; this black patch is present in four of five specimens from the type locality. Ears and flight membranes pale buff in

specimens in alcohol. Forearm 60, 61, and 62 in three individuals. The skull of the largest of these measures: greatest length 20, occipital condyle to front of canine 19.3, zygomatic breadth 11.8, front of canine to rear of last molar 8.8.

These measurements agree closely with those given for the type, and colors are very similar to those in a series of five topotypes from Terutau Island.

Specimens examined.—Total 4. Berhala Island, mouth of Sandakan Bay (1 in alcohol, 1 skinned from alcohol); Madong Awan, Tapadon (2 in alcohol).

Family MEGADERMIDAE

Megaderma spasma kinabalu Chasen.

False Vampire.

Megaderma spasma kinabalu Chasen, 1940, Bull. Raffles Mus., 15: 35.—Mt. Kinabalu, North Borneo, 3,000 ft.

Megaderma spasma trifolium Geoffroy.

Megaderma spasma trifolium Geoffroy, 1810, Ann. Mus. Hist. Nat. Paris, 15: 193.—Java.—Chasen, 1931, Bull. Raffles Mus., 15: 114 (Berhala Island).

Family NYCTERIDAE

Nycteris javanica tragata Andersen.

Hollow-faced Bat.

Petalia tragata Andersen, 1912, Ann. Mag. Nat. Hist., (8) 10: 546.—Bidi Caves, Sarawak.

Nycteris javanica tragata Chasen, 1940, Bull. Raffles Mus., 15: 36.

Reddish brown above and below, slightly darker than two specimens of *N. j. javanica* from Buitenzorg, Java. Bases of hairs buffy. Measurements of an adult male: head and body 69, tail 65, forearm 49.5.

Skull (measurements of type in parentheses): greatest length 22.4, condylo-canine length 19.4 (19.2), zygomatic breadth 13.5, canine to rear of last upper molar 8.2 (8.2).

This individual was found hanging beneath a thatch house in a clearing in secondary forest.

Specimens examined.—Sapagaya Forest Reserve (1 skin and skull).

LEAF-NOSED BATS

Family RHINOLOPHIDAE

KEY TO NORTH BORNEAN SPECIES OF *RHINOLOPHUS*

- 1 a. Sella of nose leaf with a lappet on each side, the lappets folded in towards each other (fig. 11) 2
- b. Sella without lappets 4
- 2 a. Size large (forearm about 60) *Rhinolophus luctus foetidus*
- b. Size smaller (forearm about 50 or less) 3
- 3 a. Forearm about 50. Nose leaf unpigmented *Rhinolophus trifolius trifolius*
- b. Forearm about 40. Nose leaf pigmented *Rhinolophus sedulus sedulus*
- 4 a. Sella without a dorsal connecting piece (fig. 11) *Rhinolophus creaghi*
- b. Sella with a dorsal connecting piece 5

- 5 a. Sella much higher than wide 126
 b. Sella nearly as wide as high, its lower half expanded into a broad shallow cup. Ears extremely large *Rhinolophus philippinensis sanborni*

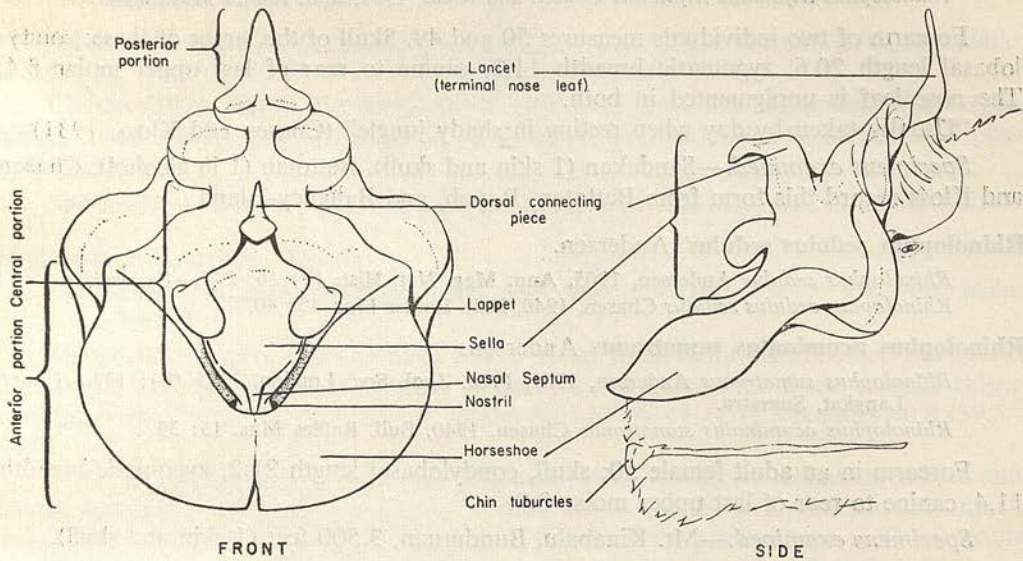


Figure 11. Diagram of nose leaf of *Rhinolophus*.

- 6 a. Sides of sella convex. Nose leaf pigmented *Rhinolophus acuminatus sumatranus*
 b. Sides of sella nearly parallel or concave. Nose leaf unpigmented 7
 7 a. Forearm about 42 *Rhinolophus borneensis borneensis*
 b. Forearm about 50 *Rhinolophus affinis nesites*

***Rhinolophus borneensis borneensis* Peters.**

Rhinolophus borneensis Peters, 1861, Monatsber. Akad. Berlin, 1861: 709.—Labuan.

Rhinolophus borneensis borneensis Andersen, 1905, Proc. Zool. Soc. London, 1905: 87.

Measurements of an adult male are: head and body 48, tail 22, forearm 42. This individual was found at 9:00 a.m., hanging from a twig four feet above the surface of a small stream in old logged forest.

Specimens examined.—Sapagaya Forest Reserve (1 in alcohol). Chasen and Kloss record this form from Rayoh, and Chasen (1931) from the Madai Caves.

***Rhinolophus affinis nesites* Andersen.**

Rhinolophus affinis nesites Andersen, 1905, Proc. Zool. Soc. London, 1905: 104.—Bunguran Island, North Natunas.

***Rhinolophus philippinensis sanborni* Chasen.**

Rhinolophus philippinensis Chasen, 1931, Bull. Raffles Mus. 5: 111.—Madai and Tapadong Caves.

Rhinolophus philippinensis sanborni Chasen, 1940, Bull. Raffles Mus., 15: 39.—Tapadong Caves, near Lahad Datu, North Borneo.

***Rhinolophus luctus foetidus* Andersen.**

Rhinolophus morio foetidus Andersen, 1918, Ann. Mag. Nat. Hist. (9) 2: 378.—Baram, Sarawak.

Rhinolophus luctus foetidus Chasen, 1940, Bull. Raffles Mus., 15: 40.

Hipposideros diadema Andersen.

Hipposideros diadema vicarius Andersen, 1905, Ann. Mag. Nat. Hist., (7) 16: 499.—Niah Cave, Sarawak.—Chasen, 1931, Bull. Raffles Mus., 5: 111 (Gomantong, Baturong, Madai, and Tapadong Caves).

Adult male, forearm 79, skull greatest length 31, condylobasal length 27.5, zygomatic breadth 18, front of canine to rear of last upper molar 12.7.

Chasen (1931) states that stomachs of specimens from the Gomantong Cave contained "beetles (including fragments of *Longicorna* sp.), Blattidae, Hemiptera and possibly some ants."

Specimens examined.—Sapagaya Forest Reserve (1 skin and skull, 1 in alcohol).

Hipposideros dyacorum Thomas.

Hipposideros dyacorum Thomas, 1902, Ann. Mag. Nat. Hist. (7) 9: 271.—Mt. Mulu, Sarawak.

Upper parts brown, bases of hairs buffy. Under parts buffy brown. Nose leaf small, pigmented, without secondary leaflets; upper part of sella with three vertical ridges dividing it into four cells. Forearm in 7 males 39.3 (37.6–41.1), in 3 females 40.8 (39.5–41.9).

First upper premolar minute and displaced from toothrow; second premolar and canine in contact. First lower premolar minute but in toothrow. Zygomatic arch much broadened vertically for a short distance in front of its posterior root. Three skulls measure: canine to condyle 14.1 (13.9–14.2), zygomatic breadth 9.3 (9.2–9.4), upper toothrow, canine to last molar, 5.4 (5.3–5.4).

Our specimens were collected in primary forest. They represent part of a colony that was roosting during the day in a large hollow log lying on the ground. The cavity in the log was about three feet in diameter and about eight feet long. Abbott (in Lyon, 1911) found this species "hanging under a rock."

Specimens examined.—Total 12. Bukit Kretam (3 skins and skulls, 9 in alcohol).

Hipposideros sabanus Thomas.

Hipposideros sabanus Thomas, 1898, Ann. Mag. Nat. Hist. (7) 1: 243.—Lawas, Sarawak.

Distinguished by the absence of 3 vertical ridges on upper part of sella. Forearm in type, an adult female, 38.

Hipposideros cineraceus Blyth.

Hipposideros cineraceus Blyth, 1853, Jour. Asiatic Soc. Bengal, 22: 410.—Punjab.

Hipposideros larvatus neglectus Sody.

Hipposideros larvatus neglectus Sody, 1936, Natuur. Tijdschr. Ned. Ind., 96: 46.—Mt. Kenepai, Dutch Central Borneo.

Hipposideros galeritus labuanensis Tomes.

Phyllorhina labuanensis Tomes, 1858, Proc. Zool. Soc. London, 1858: 538.—Labuan Island.

Hipposideros galeritus galeritus Chasen, 1931, Bull. Raffles Mus., 5: 111.

Hipposideros galeritus labuanensis Chasen, 1940, Bull. Raffles Mus., 15: 47.

Hipposideros insolens Chasen, 1940, Bull. Raffles Mus., 5: 112.

Coloration varies in a series from Sandakan. Color above chocolate to reddish brown, the anterior half of the body distinctly paler than the posterior half, the colors of the two regions sharply separated. Basal two-thirds of hairs buffy, terminal third

brown. Under parts buffy brown, the hairs brown at the base. Nose leaf heavily pigmented, with two secondary leaflets; upper part of sella with three vertical ridges dividing it into four cells. Forearm in 15 males 46.8 (45.7–48.7), in 15 females 47.2 (45.9–49.0).

First upper premolar minute, displaced from toothrow; second premolar and canine almost or quite in contact. First lower premolar large, more than half the height of next premolar, cuspidate. Zygomatic arch much broadened vertically for more than its posterior half. Four skulls measure: canine to condyle 15.6 (15.4–15.8), zygomatic breadth 10.0 (9.7–10.3), upper toothrow, canine to rear of last molar 6.7 (6.5–6.8).

Our specimens came from a large colony roosting in a small sandstone cave on the coast of Sandakan Bay. A thick layer of guano on the floor of the cave indicated that it had been used by bats for many years.

Specimens examined.—Total 34. Four miles west of Sandakan (4 skins and skulls, 30 in alcohol). Chasen (1931) recorded this species, under the names *H. g. galeritus* and *H. insolens*, from the Gomantong, Baturong, Madai, and Tapadong Caves, and from Berhala Island.

Family VESPERTILIONIDAE

KEY TO BORNEAN BATS OF THE GENUS *MYOTIS*

- 1 a. Foot large (more than half length of lower leg), calcar about twice as long as free border of interfemoral membrane 2
- b. Foot smaller (about half length of lower leg), calcar about as long as free border of interfemoral membrane *Myotis muricola muricola*
- 2 a. Forearm about 38 3
- b. Forearm about 48 *Myotis macrotarsus saba*
- 3 a. Braincase narrow and not inflated *Myotis lepidus*
- b. Braincase broader and inflated *Myotis horsfieldi carinatae*

***Myotis horsfieldi carinatae* Miller.**

Myotis carinatae Miller, 1906, Proc. U.S. Nat. Mus., 31: 62.—Karimata Island.

Myotis horsfieldi carinatae Chasen, 1931, Bull. Raffles Mus. 5: 112 (Tapadong Caves).

Forearm 38–39 in five specimens, according to Chasen.

***Myotis lepidus* Thomas.**

Leuconoe lepidus Thomas, 1915, Ann. Mag. Nat. Hist. (8) 15: 171.—Baram, Sarawak.

Myotis lepidus Chasen, 1940, Bull. Raffles Mus. 15: 48.

“Differs from the Javan *L. horsfieldi* by its much smaller and narrower brain-case, and still more from the other Sarawak and N. Bornean examples of this group, which have the brain-case more swollen than in true *horsfieldi*.”

This species seems to be known only from the type.

***Myotis macrotarsus saba* subsp. nov.**

Type.—From Semporna, Lahad Datu District, North Borneo. No. 77035 Chicago Natural History Museum. Adult female in spirit, skull removed and cleaned. Collected August 20, 1948, by J. Alan Tubb.

Diagnosis.—Similar to typical *M. macrotarsus* from the Philippines, but larger and lacking the reddish element in the coloration.

Coloration.—Colors of type temporarily dried from alcohol: upper side deep grayish brown, almost slate, heavily frosted with pale buffy gray; basal two thirds of hairs dark, terminal third pale. Under parts dirty white, the hairs only very slightly darker at the base than at the tip. Separation of coloration of upper parts and under parts sharp, at level of wing insertion.

Measurements.—Forearm 49.0, lower leg (knee to heel) 20, foot 15, ear 18. Skull, greatest length 19, canine to condyle 16.4, zygomatic breadth 11.9, front of canine to rear of last upper molar 7.4.

Remarks.—A series of ten paratypes in spirit (nos. 77030–34, 77036–40) agrees with the type in coloration; all contrast strongly with three dried skins of typical *macro-tarsus*, from Marinduque and Guimara Islands, in lacking the rufous element. Chasen (1931) described an unidentified specimen of *Myotis* from the Madai Caves near Lahad Datu that almost certainly represents *M. m. saba*. In the paratypes, mean and extreme forearm lengths in 4 males are 47.4 (46.0–48.5), in 6 females 48.2 (47.3–48.9). The skull of a paratype, an adult female, measures: canine to condyle 16.0, zygomatic breadth 11.5, front of canine to rear of last upper molar 7.3.

The type series was collected “in the cave facing the sea near roadside.”

Specimens examined.—Semporna (11 in spirit, two with skulls removed).

***Myotis muricola muricola* Hodgson.**

Vespertilio muricola Hodgson, in Gray, 1846, Cat. Mamm. Nepal, p. 4.—Nepal.

Myotis muricola muricola Chasen, 1940, Bull. Raffles Mus. 15: 49.

Color above dark brown faintly washed with paler brown; hairs dark at base tipped with rufous brown. Under parts dark brown washed with buffy gray in one specimen, dark brown washed with buffy brown in a second.

Forearm in three adult males 33.5, 36.0, 36.2, in an adult female 36.4. Skull in two adult males, canine to condyle 12.4, 12.9; canine to rear of last upper molar 5.4, 5.4.

Two Bukit Kretam specimens were taken in a cave in primary forest.

Specimens examined.—Total four. Bukit Kretam (2 skins and skulls, 1 in alcohol), Sandakan (1 skin and skull).

***Pipistrellus kitcheneri* Thomas.**

Pipistrellus kitcheneri Thomas, 1915, Ann. Mag. Nat. Hist. (8) 15: 229.—Boentok, Barito River, South Central Borneo.

Pipistrellus imbricatus kitcheneri Chasen, 1940, Bull. Raffles Mus. 15: 50.

I have a single North Bornean specimen of *Pipistrellus*, an adult male with a forearm length of 38 mm. The skull is too decalcified by formalin to permit removal. This specimen is referred to *kitcheneri* on the basis of forearm length (37 mm. in the type).

Specimens examined.—Sandakan (1 in alcohol).

***Pipistrellus tenuis* Temminck.**

Vespertilio tenuis Temminck, 1840, Mon. Mamm., 2, p. 229.—Java.

Forearm about 30.

***Pipistrellus javanicus javanicus* Gray.**

Scotophilus javanicus Gray, 1838, Mag. Zool. Bot. 2: 498.—Java.

Pipistrellus javanicus javanicus Laurie & Hill, 1954, Land Mam. New Guinea, p. 66.

Forearm about 33.

Glischropus tylopus Dobson.

Vesperugo tylopus Dobson, 1875, Proc. Zool. Soc. London, 1875: 473.—North Borneo.
Glischropus tylopus Miller, 1907, Bull. U.S. Nat. Mus. 57: 205.

Tylonycteris robustula Thomas.

Tylonycteris robustula Thomas, 1915, Ann. Mag. Nat. Hist. (8) 15: 227.—Upper Sarawak.

Hesperoptenus doriae Peters.

Vesperus (Hesperoptenus) doriae Peters, 1868, Monatsber. Akad. Berlin, 1868: 626.—Sarawak.
Hesperoptenus doriae Miller, 1907, Bull. U.S. Nat. Mus., 57: 211.

Forearm 43 in a juvenile male. Canine to rear of last upper molar 7.3. Median upper incisor large and caniniform, the area of its base much more than half that of canine. Lateral upper incisor displaced backward but visible from the front, its crown reaching well beyond the level of the cingula of the two neighboring teeth. Area of cross section of lateral incisor more than half that of median incisor.

Specimens examined.—Sapagaya Forest Reserve (1 in alcohol).

Nyctalus stenopterus Dobson.

Vesperugo stenopterus Dobson, 1873, Proc. Zool. Soc. London, 1873: 470.—Sarawak.
Nyctalus stenopterus Hollister, 1913, Proc. U.S. Nat. Mus. 46: 310.

Scotophilus temminckii castaneus Gray.

Scotophilus castaneus Gray, 1838, Mag. Zool. Bot. 2: 498.—Malacca.
Scotophilus temminckii castaneus Chasen, 1940, Bull. Raffles Mus. 15: 55.

Murina suilla Temminck.

Tube-nosed Bat.

Vespertilio suillus Temminck, 1840, Mon. Mammalia 2: 224.—Java.
Murina suillus Gray, 1842, Ann. Mag. Nat. Hist. 10: 258.

Kerivoula papillosa malayana Chasen.

Kerivoula papillosa malayana Chasen, 1940, Bull. Raffles Mus. 15: 55.—Ginting Bidai, Selangor-Pahang Boundary, Malay States, 2,300 feet.

Kerivoula hardwickii hardwickii Horsfield.

Vespertilio hardwickii Horsfield, 1824, Zool. Researches Java, unpagged.—Java.

Kerivoula picta Pallas.

Vespertilio pictus Pallas, 1767, Spic. Zool. 3: 7.—Peninsular India.

Kerivoula pusilla Thomas.

Kerivoula pusilla Thomas, 1894, Ann. Mag. Nat. Hist. (6) 14: 461.—Mt. Mulu, Sarawak.

Kerivoula bombifrons Lyon.

Kerivoula bombifrons Lyon, 1911, Proc. U.S. Nat. Mus. 40: 135.—Matan River, Dutch West Borneo.

Miniopterus schreibersi blepotis Temminck.

Vespertilio blepotis Temminck, 1840, Mon. Mammalia 2: 212.—Java.
Miniopterus blepotis Chasen, 1931, Bull. Raffles Mus. 5: 113 (Baturong, Madai, and Tapadong Caves).

Miniopterus australis pusillus Dobson.

Miniopterus pusillus Dobson, 1876, Monogr. Asiatic Chiroptera, 162.—Madras, India.
Miniopterus witkampii Chasen, 1931, Bull. Raffles Mus., 5: 113 (Madai, and Tapadong Caves).

Family MOLOSSIDAE

Tadarida plicata plicata Buchannan.

Wrinkle-lipped Bat.

Vespertilio plicatus Buchannan, 1800, Trans. Linn. Soc. London, 5: 261.—Bengal.*Ch[aerephon] plicatus* Andersen, 1907, Ann. Mus. Civ. Stor. Nat. Genova (3) 3: 40.*Chaerephon plicatus* Chasen, 1931, Bull. Raffles Mus. 5: 114 (Madai Caves, North Borneo).*Chaerephon plicatus plicatus* Chasen, 1940, Bull. Raffles Mus. 15: 58.*Tadarida plicata plicata* Ellerman and Morrison-Scott, 1951, Checklist Pal. Indian Mam., p. 135.

I have a single specimen of this form from North Borneo. Color above (from specimen temporarily dried from alcohol) very dark reddish brown, darker than specimens of *T. p. luzona* and more reddish than specimens of *T. p. plicata* from Java. Hairs buffy white at base, as in *luzona*; bases of hairs are much darker in Javanese *plicata*. Underparts rufous buff, almost indistinguishable from *luzona* and much paler—particularly on throat and neck—than *plicata*. Bases of hairs buff, followed by a buffy brown band, and tipped with rufous buff, as in *luzona*.

Head and body 63, tail 33, forearm 42.5. Skull, greatest length 18.7, condylobasal length 17.5, zygomatic breadth 11.2, canine to last upper molar 7.0. This specimen, an adult male, is slightly smaller than the one reported by Chasen (1931), in which the forearm measured 45.

These North Bornean bats have shorter forearms than the average for 25 Javanese *T. p. plicata* in Chicago Natural History Museum and the U.S. National Museum, in which mean and extreme forearm lengths are 47.4 (44.0–50.0). Mean skull measurements of 12 of the Javanese specimens are almost identical with those of our Bornean specimen. Forearm length in the Bornean individual is slightly greater than in *T. p. luzona* (mean 42.4, extremes 41–43.5 in 13 specimens), but the skull in *luzona* is much smaller in all dimensions.

Specimens examined.—Sapagaya Forest Reserve (1 in alcohol). Chasen records this species from the Madai Caves.

Cheiromeles torquatus torquatus Horsfield.

Hairless Bat.

Cheiromeles torquatus Horsfield, 1824, Zool. Res. Java, no. 8 (unpaged).—Penang.

PRIMATES

Borneo has one of the richest primate faunas of any country in the world. Many species, particularly of treeshrews and leaf monkeys, have broken up into numerous local races on Borneo. The limits of the ranges of these subspecies are not well known.

TREESHREWS

Family TUPAIIDAE

Next to the squirrels, treeshrews are the commonest mammals seen in the Bornean forest. This is partly because all, except the pen-tailed treeshrew, are diurnal and are usually found either on the ground or in the lower stories of the forest. The terrestrial treeshrew (*Tupaia tana*) has broken up into a number of local races, distinguished chiefly by color differences, but this appears to be less true of the other species.

The treeshrews range through the Oriental tropics from India and southern China to Mindanao in the Philippines. They reach their maximum diversity in Borneo, where at least nine species representing three well-marked genera occur. Seven species representing three genera are known from North Borneo; one of these, *Dendrogale melanura*, is known only from Kinabalu.

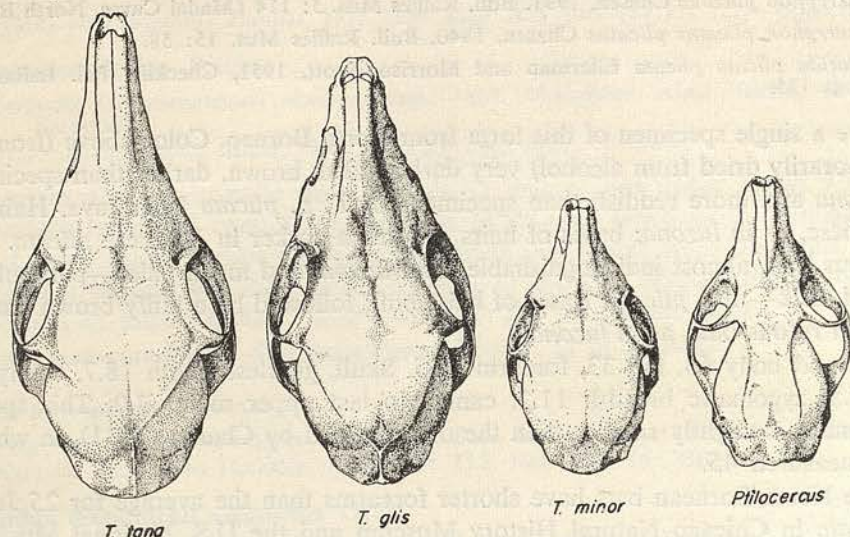


Figure 12. Skulls of Bornean treeshrews (genera *Tupaia* and *Ptilocercus*) in dorsal view. All specimens except *T. minor* from Sapagaya Forest Reserve; *T. minor* from Bukit Kretam. X 1.

KEY TO THE TREESHREWS OF NORTH BORNEO

- 1 a. Basal part of tail naked, with a flattened tuft of hairs at tip *Ptilocercus*
 b. Tail haired throughout its whole length, without a conspicuous tuft at tip 2
- 2 a. Tail rounded and short-haired for its whole length. (Mt. Kinabalu only) *Dendrogale*
 b. Tail clothed with longer hairs, squirrel-like in character 3
- 3 a. Size small, head and body less than 150 mm., tail longer than head and body, general color olive-brown above 4
 b. Size large, head and body more than 160 mm., tail equal to or shorter than head and body 6
- 4 a. Hind foot about 40 mm. *Tupaia gracilis gracilis*
 b. Hind foot about 32 mm. 5
- 5 a. Back with a brownish wash; shoulder stripe conspicuous (western North Borneo) *Tupaia minor minor*
 b. Back usually lacking a brownish wash; shoulder stripe narrow and inconspicuous (northeastern North Borneo) *Tupaia minor caedis*
- 6 a. Form slender; tail about as long as head and body; general color uniform blackish-brown above *Tupaia glis longipes*
 b. Form stocky; tail shorter than head and body; a median black stripe on back 7
- 7 a. Black dorsal stripe on anterior half of body only, ending in a large black patch on rump .. 8
 b. Black dorsal stripe extending entire length of body; rump rufous *Tupaia dorsalis*
- 8 a. Tail buff-colored, contrasting sharply with color of rest of body (mainland opposite Labuan) *Tupaia tana chrysura*
 b. Tail not contrasting sharply with color of body 9
- 9 a. Pale area on either side of midline on underside of tail rufous (northeastern North Borneo) *Tupaia tana paitana*
 b. Pale area on either side of midline on underside of tail buff-colored (Dewhurst Bay area) *Tupaia tana kretami*

Terrestrial Treeshrews

(Tupaia tana)

The terrestrial treeshrews are characterized by a stocky body, a long pointed snout, and a short tail. The naked rhinarium is continued back into the haired area on the top of the nose for a short distance, instead of being limited to the tip of the nose and cut squarely across as in other treeshrews. The claws on the forefeet are very large. Lyon (1913) proposed a separate genus, *Tana*⁵, for *Tupaia tana* on the basis of the elongated rostrum and recession of the rhinarium (shared also by *Urogale* of the Philippines), but I agree with Chasen and Kloss that these characters do not warrant generic distinction. *Tupaia tana* is found on Borneo and Sumatra and certain of the small adjacent islands. It has broken up into several races on Borneo; without much more collecting it is impossible to decide which of the numerous proposed names should be retained.

The sides of the body and outer sides of the legs are bright hazel, top of head and anterior part of back olive or buff finely streaked with black or dark brown. A narrow light-colored stripe passes diagonally across the shoulder. A black stripe begins on the nape and runs back along the dorsal midline, expanding into a black area of variable extent on the rump. Belly rufous or buff. The color of the tail varies considerably among individuals, and from subspecies to subspecies. The tail is markedly distichous, viewed from below.

Mammæ 2 — 2 = 4.

These are among the largest of the treeshrews, and in North Borneo are the ones most commonly seen. They are almost exclusively terrestrial, and are the least squirrel-like of the treeshrews in appearance and behaviour. They are almost always observed scurrying about the forest floor or climbing over fallen logs, and are rarely seen even in the lowest branches of trees. When pursued they do not resort to climbing, but escape on the ground. The usual posture is with the body held close to the ground, the head raised and the tip of the tail curled slightly upward. They are active and nervous in their movements. Nothing is known of their home life or nesting habits.

Stomach contents of ten individuals, from both primary and old logged forest in the Bukit Kretam and Sapagaya areas, were examined. Earthworms (present in 7 stomachs) and arthropods (present in all stomachs) predominate. Lepidopteran larvae were present in 4 stomachs, and ants in 4; some of the ants are minute (a millimeter or less in length). One stomach was nearly filled with winged termites, along with a few workers and a few fragments of other insects. Four stomachs contained recognizable fruit remains. Other food items include centipedes, beetle larvae, orthopteroid egg cases, and mites. Fragments of dead leaves and small pieces of rotten wood are common. Parasitic roundworms are sparsely represented in two stomachs.

Earthworms are in sections about 10 mm. long, centipedes and caterpillars are mostly entire, and beetles and orthopteroids are fragmented into small pieces. Except for the higher frequency of fruit, the diet of *Tupaia tana* appears to be strikingly similar to that of *Echinosorex* and differs considerably from the diet of *Tupaia glis*. Prey animals are characteristic of forest litter and decaying log situations, and this is reinforced by the frequency of bits of dead leaves and rotten wood in stomachs. Thus it appears that

5. Now *Lyonogale*. See Conisbee, 1953, A list of the names proposed for genera and subgenera of recent mammals, p. 46. London, Brit. Mus. (Nat. Hist.).

Tupaia tana, a diurnal species, and *Echinosorex*, a nocturnal species, may be exploiting essentially the same situation on an alternating shift basis, whereas the two terrestrial treeshrews, *Tupaia tana* and *T. glis*, operate in slightly different ecological niches.

Of 15 fully adult females collected between April 15 and August 3, only three were pregnant. These were taken on July 16, July 25, and July 29. Each contained two embryos.

Mean and extreme weights of 25 adults were 221 (160–260) grams.

***Tupaia tana paitana* Lyon.**

(Plate 9).

Tana paitana Lyon, 1913, Proc. U.S. Nat. Mus. 45: 150.—Paitan River, North Borneo.

Tupaia tana paitana Chasen and Kloss, 1931, Bull. Raffles Mus. 6: 42.

Distinguished from *Tupaia tana utara* of Sarawak by greater development of the paler olive or buff area on either side of the dorsal stripe. In *utara* the reddish brown of the sides embraces the shoulder stripe, whereas in *paitana* according to Lyon the paler color on either side of the dorsal stripe embraces the shoulder stripe. Our series exhibits a good deal of variation; ten show the *paitana* pattern while in seven the shoulder stripe is bordered by reddish-brown below and by the paler dorsal color above. In five specimens the shoulder stripe is almost extinct. There is much variation in the extent of blackening on the rump. There is usually a distinct area of blackening, grading off into the rufous of the hips and flanks. In one specimen the black is reduced to a mere continuation of the dorsal stripe, producing an effect similar to *Tupaia dorsalis*⁶ and two other specimens approach this. Three specimens from Deramakot closely resemble the Sandakan Bay series, except that the belly is slightly less rufous. All specimens from eastern North Borneo are distinctly paler, except for the black areas, than a topotype from Paitan.

Mean and extreme head and body lengths of 12 adults from the Sapagaya Forest Reserve are 208.6 ± 1.55 (200–219); tail 172 (158–181); hind foot 48.8 (47–51). Skull measurements of the same 12 specimens are: greatest length 60.9 (58.7–63.2), condylobasal length $57.2 \pm .353$ (55.5–59.6), zygomatic breadth 27.8 (26.2–28.9), palatal length 34.2 (32.7–36), upper cheek teeth (not including canine) $17.9 \pm .118$ (17.3–18.6). These measurements compare favorably with those given by Chasen and Kloss for nine specimens from Samawang and Bettotan.

Specimens examined.—Total 22. Sandakan mi. 8 (3), Sapagaya Forest Reserve (15), Deramakot (3), Paitan (1). Other records are: Samawang River and Bettotan (Chasen and Kloss).

***Tupaia tana kretami* subsp. nov.**

Type.—From Bukit Kretam, southeast end of Dewhurst Bay, Kinabatangan District, North Borneo. No. 68794 Chicago Natural History Museum. Adult male. Collected 5 June 1950 by D. Dwight Davis. Original number 290.

Diagnosis.—Similar to *T. t. paitana* Lyon, but pale area on either side of midline on underside of tail buffy instead of rufous. Belly less rufous than in *paitana*, and throat reddish-yellow instead of buff. Black area on rump tending to be more extensive than in *paitana*. In size *kretami* is slightly smaller than *paitana*.

6. Chasen and Kloss identified four specimens from Samawang and Bettotan as *Tupaia dorsalis*, but these probably represent extreme reduction of the black rump patch in *T. t. paitana*. The measurements in their table (p. 73) are confused; several columns of figures obviously have been interchanged.

Measurements.—Type: total length 383, tail 163, hind foot 47. Skull of type: greatest length 59.6, condylobasal length 55, zygomatic breadth 27, upper premolar-molar series 17.8.

Remarks.—A series of 10 specimens from the type locality agrees closely with the type in the colors of the underside of the tail, belly, and throat. The colors of the upper side of the body and tail are much more variable. In six specimens the rufous of the sides embraces the shoulder stripe (as in *utara*), in three it reaches only to the lower border of the shoulder stripe, and in two the shoulder stripe is embraced by the paler dorsal color (as in *paitana*). The extent of the black rump patch is variable; it averages more extensive than in *paitana*, but when least developed is less extensive than in the darkest *paitana*.

Mean and extreme measurements for the type and nine adult paratypes of *kretami* are: head and body 204.7 ± 2.98 (190–220), tail 160 (135–180), hind foot 46.4 (43–50). Skull measurements of these 10 specimens are: greatest length $58.5 \pm .336$ (57.5–60.5), condylobasal length $54.5 \pm .210$ (53.8–56), zygomatic breadth $27.4 \pm .20$ (26.2–28), palatal length $32.5 \pm .207$ (31.5–33.5), upper cheek teeth (not including canine) $17.2 \pm .17$ (16.3–17.8). The differences between the means of *kretami* and *paitana* are statistically significant; for condylobasal length $t^7 = 6.14$, $P = < .001$; for upper cheek teeth $t = 3.67$, $P = .003$.

Specimens examined.—Bukit Kretam (11).

***Tupaia tana chrysura* Günther.**

Tupaia tana var. *chrysura* Günther, 1876, Proc. Zool. Soc. London, 1876: 427.—Borneo, opposite Labuan Island.

Tupaia tana chrysura Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 43.

Like *Tupaia t. paitana*, but entire tail buff-colored above and below, contrasting sharply with color of body. The general body color is less reddish than in *paitana*, and the belly is yellow or orange, less rufous than in *paitana*. Shoulder stripe white.

Measurements of a small female are given by Chasen and Kloss as: head and body 192; tail 175; hind foot 44; greatest skull length 57, basal length 53.5, upper toothrow 16.4.

Locality records.—Lumbidan, directly opposite Labuan (Lyon); Rayoh (Chasen and Kloss).

Two additional subspecies, of doubtful status, have been described from North Borneo. These are *Tupaia tana banguei* Chasen and Kloss (1931, Bull. Raffles Mus., 6: 44) from Banguet Island, said to differ very slightly in size and color from *paitana* from the adjacent mainland; and *Tupaia tana griswoldi* Coolidge (1938, Proc. New Engl. Zool. Club, 17: 45) from Kiau at 3,300 feet on Mt. Kinabalu.

***Tupaia dorsalis* Schlegel.**

Striped Treeshrew.

Tupaja dorsalis Schlegel, 1857, Handl. Beoef. Dierk., p. 59.—Lower Kapuas River, West Borneo.

This species is well characterized by the conspicuous narrow black stripe extending from the nape almost to the base of the tail. Shoulder region, sides of body, and outer sides of front legs olivaceous, very similar to the color of *Tupaia minor*; hairs slate-colored at their bases. Shoulder stripe narrow, well-defined, whitish. Top of head rufous.

7. This is Student's *t*. (See C. B. Davenport).

Rump, base of tail and outer side of thighs rufous, brighter than top of head. A narrow (2–3 mm.) sharply-defined black stripe extending from nape almost to base of tail, the stripe gradually narrowing posteriorly. Belly buff, washed with gray, in the single North Bornean specimen known. Tail darker than body above, a wide poorly-defined rufous stripe along midline below.

Mammae 2 — 2 = 4.

Measurements of the single known specimen, an adult male, are: head and body 161, tail 145, hind foot 46. Skull: greatest length 47.7, condylobasal length 44, zygomatic breadth 19.7, palatal length 25.9, upper cheek teeth (not including canine) 14.1. Weight 105 grams.

Nothing is known of the habits of this species. Our specimen was taken on the ground in logged dipterocarp forest. A second individual, from Mt. Matang in Sarawak, was also on the ground. The claws on the forefeet are not enlarged as they are in *Tupaia tana*.

Specimens examined.—Kalabakan, Sungei Tibas (1).

***Tupaia glis longipes* Thomas.**

Slender Treeshrew.

Tupaia ferruginea longipes Thomas, 1893, Ann. Mag. Nat. Hist., (6) 11: 343.—Northwest Borneo.

Tupaia longipes longipes Lyon, 1913, Proc. U.S. Nat. Mus., 45: 76.

Tupaia glis longipes Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 39.

A large slender-bodied treeshrew, with the muzzle less elongated than in *Tupaia tana* and the tail about as long as the head and body. General color above, from snout to tip of tail and including outer sides of legs, an agouti pattern of brown or reddish-brown finely speckled with black. There is a short orange-colored shoulder stripe, which is almost or quite obsolete in some individuals. Throat buff, becoming reddish at the sides. Chest orange-yellow, typically paler in the centre, belly buff; undersides of legs similar to adjacent areas of underparts. Underside of tail buff lightly speckled with black at midline, becoming darker toward the margins, markedly distichous.

Mammae 3 — 3 = 6.

Mean and extreme head-and-body lengths of 15 adults from Bukit Kretam and the Sapagaya Forest Reserve 195 (174–211); tail 187 (176–200) hind foot 49.0 (46–52). Skull measurements of the same 15 specimens are: greatest length 52.2 (50.8–53.8), condylobasal length 49.2 ± .226 (47.6–50.4), zygomatic breadth 26.6 (25.5–27.4) palatal length 28.7 (27.4–29.6), upper cheek teeth (not including canine) 17.0 ± .118 (16.4–17.8).

The mean weight of 12 adult individuals was 173 gms., extremes 150–190.

This species was less common than the terrestrial treeshrew (*Tupaia tana*). Its habits are generally similar. It is strictly diurnal, and all individuals observed were on the ground or on fallen trees. A captive made repeated piercing bleating sounds, alternating with cat-like spitting, when handled, and bit savagely at anything within range. It ate fruit, especially bananas, greedily. Pieces of food were held between the forepaws during feeding. Water was lapped with the tongue.

Stomach contents of six individuals, from both primary and old logged forest in the Bukit Kretam and Sapagaya area, were examined. The dominant food items were fruits and ants. Fruits of several kinds were present in 4 stomachs; in two they made up more

than half the bulk of the contents, and in a third they accounted for about half. Ants were present in all 6 stomachs; in 3 they were present in considerable numbers (up to several hundred individuals). Termites were identified in 4 stomachs; in one they were present in considerable numbers. The remainder of the food items included beetles and beetle larvae, orthopteroids, hemipterans, spiders, and arthropod egg and pupa cases. The insects were fragmented to about the same degree as in *Tupaia tana*. There were a very few leaf and bark fragments, and no pieces of rotted wood.

The nature of the stomach contents indicates that *Tupaia glis* forages on the surface of the forest floor. There is no evidence that it digs or scratches in forest litter or decaying-log situations as *T. tana* seems to do: earthworms, centipedes, and rotted-wood fragments are absent from the stomachs of the slender treeshrew. Robinson and Kloss (in Thomas, 1909, Jour. Fed. Malay States Mus., 4: 112) state that the diet of the closely related *T. glis ferruginea* on Singapore Island is "very mixed, consisting of ants and other insects, fruit, seeds, and buds." They state further that "the nest is found in holes, often in fallen timber."

Of ten adult females collected between April 27 and August 10, only two were pregnant. These were taken on July 14 and August 10, and each contained two embryos.

Locality Records.—Total 20. Bukit Kretam (7), Sapagaya Forest Reserve (9), Sandakan (1), Sandakan mi. 8 (1), Deramakot (1), Kalabakan (1). Chasen and Kloss record it from Bettotan and Rayoh, and Lyon from Spitang (Sipitang).

Pigmy Treeshrews

(*Tupaia minor*)

These are the smallest members of the genus *Tupaia*. They are characterized by small size, uniform olive color, and very long and rather narrow tail. The tail is invariably longer than the head and body, often by as much as 20 per cent. There are two poorly defined subspecies in North Borneo.

General color above, including outer sides of legs, olivaceous finely ticked with slate, usually with a reddish wash especially over the lower back; hairs slate-colored at base. Shoulder stripe narrow and indistinct, whitish in color. Belly varying from white to buff, the hairs not darker at their bases. Tail darker than body above, sometimes almost black; a wide poorly defined paler colored line along midline below.

Mammæ 2 — 2 = 4.

Mean and extreme head and body lengths of 16 adults from the Sapagaya Forest Reserve and Bukit Kretam are 128 (116–135), tail 143.3 (131–158), hind foot 32.2 (30–34). Skull measurements of the same specimens, plus three additional skulls from Sandakan, are: greatest length 35.6 (34.2–37.3), condylobasal length $33.56 \pm .187$ (32.3–34.9), zygomatic breadth 19.6 (18–21), palatal length 17.7 (17–18.5), upper cheek teeth (C—M3) $12.86 \pm .063$ (11.8–12.9). Mean and extreme weights of ten adult animals were 47 (30–60) grams.

The pigmy treeshrew is much more arboreal than *T. tana* or *T. glis*. It is one of the commonest mammals of the rain-forest, where it is often seen in the small trees and vines of the lower middle story. All the individuals we observed were, with a single exception, on small trees or vines of the lower middle story, between five feet and about 50 feet from the ground. One individual was observed on the ground. Like other species

of *Tupaia*, the pigmy treeshrew is diurnal. Little is known of its habits. Hose (1893) states that "it breeds in a nest in an old stump covered with creepers, but I am not sure whether it makes the nest itself or occupies the nest of a bird. I have found two of these nests, but the material used was different." Of nine adult females we collected between May 8 and August 1, four were pregnant. These were taken on June 1, June 30, July 16, and July 26. Each contained two embryos.

Stomach contents of seven individuals of *T. minor caedis*, from both primary and old logged forest, were examined. Food items consisted exclusively of arthropods and fruits, with insects representing the bulk of the food. Beetles, roaches, crickets, hymenopterans, flies, lepidopteran larvae, and ants were recognizable among the arthropod remains. Some individuals would have measured up to 50 mm. in length, while others were minute. Fruit remains were present in three stomachs.

Food items were finely fragmented, more so than in *Tupaia tana*. Only four small flies, each less than a millimeter long and all present in a single stomach, were entire. Absence of earthworms, centipedes, and fragments of dead leaves and rotten wood—common in the stomachs of *T. tana*—is notable. The pigmy treeshrew apparently does not feed on the forest floor.

***Tupaia minor minor* Günther.**

Tupaia minor Günther, 1876, Proc. Zool. Soc. London, 1876: 426.—Borneo, mainland opposite Labuan.

Tupaia minor minor (part) Lyon, 1913, Proc. U.S. Nat. Mus., 45: 110.

Tupaia minor minor Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 40.

Said by Chasen and Kloss to differ from the following subspecies by having the upper parts browner and the shoulder stripe wider and whiter. These authors give the known range of this form in North Borneo as the west coast from the Padas River south into Sarawak. Allen and Coolidge (1940) identified specimens from Mt. Kinabalu 2,000–3,000 feet and the Kalabakan River as *minor* (our Kalabakan specimen is definitely *caedis*).

Locality records.—Rayoh (Chasen and Kloss); Mt. Kinabalu 2,000–3,000 feet and Kalabakan River (Allen and Coolidge).

***Tupaia minor caedis* Chasen and Kloss.**

(Plate 9).

Tupaia minor caedis Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 40.—Balambangan Island, North Borneo.

This form, supposedly confined to northeastern North Borneo, is said to differ from *T. m. minor* in lacking the brownish wash on the upper parts and having the shoulder stripe narrower and pale buff in color. This is at best a very poorly defined race. All our specimens from Sapagaya Forest Reserve and the Dewhurst Bay area, with two or three exceptions, show at least a slight reddish-brown wash on the rump, and this is likewise true of the Deramakot specimen. Some specimens are almost entirely reddish above, even including the tail. The shoulder stripe is uniformly narrow, poorly defined, and pale buff in color. Whether *caedis* actually represents a distinct population must await the results of further collecting. Chasen and Kloss give the known range as from Kudat on the west coast of Marudu Bay southeast to Sandakan Bay. Our specimens extend the range farther southeast to Cowie Harbour.

Specimens examined.—Total 26. Bukit Kretam (12), Sapagaya Forest Reserve (9), Sandakan mi. 5 (2), Sandakan mi. 8 (1), Deramakot (1), Kalabakan (1). Chasen and Kloss record it from Balambangan Island, Banguay Island, Kudat, Samawang, and Bettotan.

***Tupaia gracilis gracilis* Thomas.**

Tupaia gracilis Thomas, 1893, Ann. Mag. Nat. Hist. (6) 12: 53.—Base of Mt. Batu Song, Baram, Northern Sarawak.

Tupaia gracilis gracilis Lyon, 1913, Proc. U.S. Nat. Mus., 45: 117.

This species is almost indistinguishable from the pigmy treeshrew except for its larger size. Specimens can be identified with certainty only from hind foot and skull measurements. The general color is finely grizzled olive, without the rufous wash usually present in *T. minor*. Shoulder stripe narrow and indistinct, pale buff in color. Belly dirty white to pale buff, sometimes washed with yellowish buff on the throat and chest. The tail is slightly darker than the body above, its underside with a reddish to olive line along the midline, then a band of buff outside of which the hairs are colored like the upper side. The tail is bushier than in *T. minor*.

Mammæ 2 — 2 = 4.

Measurements of an adult female from Bukit Kretam are: head and body 138, tail 173, hind foot 40; skull, greatest length 39, condylobasal length 36.2, zygomatic breadth 21.3, palatal length 19, upper cheek teeth 12.3. This individual weighed 60 grams.

The habits of this species are apparently like *T. minor*, although it is much less common. Both individuals we collected were in primary forest, one of them in a tree about six feet from the ground.

Specimens examined.—Bukit Kretam (2). Chasen and Kloss record it from Samawang, Bettotan, Rayoh, and Banguay Island.

***Ptilocercus lowii lowii* Gray.**

Pen-tailed Treeshrew.

Ptilocercus lowii Gray, 1848, Proc. Zool. Soc. London, 1848: 23.—Kuching, Sarawak.

[*Ptilocercus lowi lowi*] Thomas, 1910, Ann. Mag. Nat. Hist. (8) 5: 426.

The pen-tailed treeshrew differs very strikingly from the other treeshrews in appearance and habits, and various anatomical details emphasize its distinctness. The large naked membranous ears and its tail, naked for more than its proximal half and with a conspicuous white distichous plume distally, distinguish it from other treeshrews at once. The feet are relatively larger than in *Tupaia*, and the toes are spread more widely.

General color gray above and below, more or less washed with buff. A black or dark brown mark extends backward through the eye, but does not reach the ear. Feet white. The naked part of the tail is gray, the plume white except for a few dark hairs proximally.

Mammæ 2 — 2 = 4.

According to Lyon the "usual measurements of adults" are: head and body 135–150, tail 160–180, hind foot 27–28. Skull measurements of an adult male from the Sapagaya Forest Reserve are: greatest length 36.8, condylobasal length 35.5, zygomatic breadth 21.4, palatal length 17, upper toothrow 12.4.

Little is known of the habits of this rare animal. In nature it is exclusively nocturnal, and Banks (1931) says that some he had in captivity "used to spend most of the day asleep and only come out in the evening." The single specimen we collected was in old

logged forest, ten feet above ground on a vine about an inch in diameter, at 9:00 p.m. Robinson⁸ states that a specimen was captured in the Malay Peninsula "in its nest in a hollow bough . . . The nest was merely a tunnel about 3 in. in diameter and 18 in. in length, roughly lined with fibrous material and green leaves." Banks says his captive slept with the tail plume covering the face, and that locomotion on the ground was "in a series of hops, the tip of the tail inclined upwards." Our specimen had a musky shrew-like odor.

Specimens examined.—Sapagaya Forest Reserve (1 skeleton).

LORISES

Family LORISIDAE

Lorises from all parts of Borneo are allocated to the single subspecies *borneanus*. There is relatively little material of the Bornean loris in collections, and adequate series from various parts of the island might show that several subspecies are represented.

According to Lyon (1906) the Bornean loris never has more than two upper incisors (one on each side), while specimens from the mainland, Java, and Sumatra may have two, three, or four.

Nycticebus coucang borneanus Lyon.

Slow Loris, *Oukang*. (Plate 10).

Nycticebus borneanus Lyon, 1906, Proc. U.S. Nat. Mus., 31: 535.—Sakaiak River (tributary of Kapuas), Sanggau District, Dutch West Borneo.

Nycticebus coucang borneanus Chasen, 1940, Bull. Raffles Mus., 15: 89.

The slow loris is so distinctive that it scarcely needs description. The Bornean form is the smallest of the species. It is distinguished by a single upper incisor and the fact that the temporal ridges on the skull are widely separated, never meeting to form a sagittal crest; these are characters of dwarfing. The pelage is soft and silky, consisting of a dense woolly underfur and a longer outer coat. Coloration in *borneanus* is very variable. In one of our specimens (an adult male in alcohol) the general color is light golden brown above and below, including the legs. The basal half of the underfur is light gray everywhere except on the lower legs and feet. A white line begins at the root of the nose and extends upward between the eyes onto the forehead. The dark patch surrounding the eye is scarcely indicated, and the cheeks are colored like the rest of the body, not light colored. A light brown stripe, somewhat reddish anteriorly, begins on the top of the head by fusing of the eye patches, and extends to the middle of the back before it washes out. The nose, lips, and soles of the feet are flesh colored. The Deramakot specimen is similar, except that the general color is darker, with much frosting, with dark eye rings and the dorsal stripe extending to the root of the tail.

Measurements of our two specimens, both males, are: head and body 275, 199; tail 13, 15; hind foot 57, 51. Skull measurements of the smaller individual (young adult): greatest length 51.2, condylobasal length 47, palatal length 18.7, zygomatic breadth 32.8, upper tooththrow (C—M²) 17.6. Weight 230 gms.

This animal is exclusively nocturnal and arboreal. It is not uncommon, but relatively little is known of its habits. Our Kalabakan specimen was taken at 9 p.m. in logged dipterocarp forest, 7 feet above ground. According to Hose (1893) the Bornean loris "feeds on leaves and shoots of trees, fruits, insects, birds' eggs, and young birds." Banks states

⁸ Jour. Straits Br. Roy. Asiatic Soc., 44: 225. 1905.

that he has "seen it catching butterflies and cockroaches in its cage with great skill." Gorter (1934), who kept several individuals of *javanicus* in captivity for a year and a half, states that the approach to prey is slow and deliberate, but the final seizing is "quick as lightning;" prey is caught with the hands, sometimes with both hands together. The same author says their climbing ability is amazing, although movements are slow and deliberate, the limbs advanced one at a time. The grasping power of hand and foot is very great, says Gorter; a loris holding fast to a branch with two feet cannot be detached without opening the toes one by one. They never let themselves fall, even though only a few inches from the ground, and wild-caught animals do not allow themselves to be picked up, grasping frantically at any available object or on a flat surface spreading the feet as far as possible in order to secure a better grip.

The loris sleeps rolled up into a ball, the head and hands buried between the thighs. In captivity it is sulky and untameable; it sleeps all day but becomes active and surprisingly agile at night.

A single young is produced (Hose, Banks), and it clings tightly to the fur of its mother. A baby observed by Gorter was always carried diagonally across its mother's belly.

Specimens examined.—Sandakan (1, in alcohol), Kalabakan (1).

TARSIERS

Family Tarsiidae

The tarsiers are a very small group of isolated and extremely specialized prosimians, all referable to the single genus *Tarsius*. They are confined to eastern Sumatra, Borneo, the smaller islands of Banka, Billiton, and the Natunas; to Mindanao, Bohol, Leyte, and Samar in the Philippines; and to Celebes and its offshore islands. This is an atypical relict distribution; tarsiers are absent from Java and Palawan on the western side of Wallace's Line (Huxley's modification), present in the Philippines and Celebes on the eastern side. In view of the slight differentiation of the Philippine and Celebesian forms, there can be little doubt that *Tarsius* arrived in these two areas by waiving from Borneo.

The tarsier is apparently found over all of Borneo in lowland forest. Specimens from all parts of the island are referred to the subspecies *borneanus*.

***Tarsius bancanus borneanus* Elliott.**

Tarsier, *Sempalili*. (Plate 11).

Tarsius borneanus Elliott, 1910, Bull. Amer. Mus. Nat. Hist., 28: 153.—Landak River (tributary of Kapuas), Dutch West Borneo.

Tarsius tarsier borneanus Chasen, 1940, Bull. Raffles Mus., 15: 86.

Tarsius bancanus borneanus Hill, 1955, Primates, vol. 2, p. 241.

The tarsier is so distinctive in appearance that it can scarcely be confused with any other mammal. It is about the size of a large rat, with a short muzzle, enormous circular eyes with a light yellow-brown iris, and large naked ears that can be folded like the ears of certain bats. The fore legs are of normal size, but the hands are large, with five slender fingers each with an enlarged terminal pad surmounted by a pointed nail. The hind legs are greatly elongated, especially the tarsal section, and the feet are smaller than the hands but with similar slender digits provided with terminal pads. There is a prominent claw, at right angles to the axis of the digit, on the second and third toes. Tail more than a third longer than head and body, slender and almost hairless except for a tuft of short hairs on the distal quarter. Underside of tail naked, with longitudinal

papillary ridges along its entire length; near the base of the tail these tend to converge toward the ventral midline. Three pairs of mammae, two pectoral and one abdominal.

The pelage is soft and woolly, dense on the back and sides, thin on the throat and belly. The boundary between the thickly haired sides and the thinly haired belly is abrupt and sharp. A series of eight skins from Dewhurst Bay, Sapagaya Forest Reserve, and Sandakan shows little variation in color. The color above is light reddish brown, more reddish on top of head, and becoming yellowish brown on the rump and lower arms and legs; bases of hairs slate color. Hairs of thorax gray tipped with buff, abdomen naked or very thinly covered with gray hairs. Perineum and inner side of thighs pale buff, *not white*. Underside of tarsus densely covered with buff-colored hairs. The hairs of the tail tuft are brown-tipped, lighter at the base, giving a bicolor appearance to the tuft. Naked part of tail dark brown. Clark (1942) stated that the reddish areas were distinctly more marked in females in a series of specimens from Kuching, Sarawak, but this is not true in our series from North Borneo.

Mean and extreme head and body lengths of four adults from North Borneo are 133 (121–154), tail 214 (203–224), hind foot (5 adults) 65.8 (64–70). The mean hind foot length of 15 adult Mindanao specimens of *syrichta* is 63.6, slightly less than in the Bornean material. The Mindanao series reveals considerable sexual dimorphism in hind foot length, which is not evident in the smaller Bornean series: 5 males 66.2 (65–67), 10 females 62.3 (55–67).

Skull measurements of North Bornean specimens, compared with a large series of *syrichta* from Mindanao, are given in the accompanying table.

		North Borneo	Mindanao, P.I.
No. of specimens	...	8	42
Greatest length	...	39.1 (37.8–40.1)	39.2 (37.2–41.2)
Basal length	...	28.7 (27.8–29.5)	27.5 (26.1–28.9)
Palatal length	...	17.7 (16.7–18.2)	15.6 (14.5–16.4)
Zygomatic breadth	...	28.7 (28.2–29.5)	27.6 (25.8–29.4)
Biorbital breadth	...	34.2 (33.0–35.2)	32.1 (30.5–33.7)
Interorbital breadth	...	2.5 (2.0– 3.0)	2.0 (1.6– 2.8)
Breadth braincase	...	22.8 (22.3–23.3)	23.1 (21.6–24.5)
Breadth M ² —M ²	...	18.0 (17.5–18.4)	16.3 (15.3–17.2)
Length C—M ³	...	15.0 (14.6–15.5)	13.7 (13.0–14.3)
Breadth M ²	...	4.7 (4.4– 4.9)	3.9 (3.6– 4.3)

The most obvious difference between these two samples is the much larger cheek teeth in *borneanus*. Associated with the larger teeth is a larger facial part of the skull, which is reflected in all measurements involving that region.

Hill (1955) distinguishes three species of *Tarsius*—*syrichta* from the Philippines, *bancanus* from Malaysia, and *spectrum* from Celebes. *T. bancanus* is said to differ from *T. syrichta* in having the tail deeply pigmented dorsally, its terminal pencil heavier but less extensive, naked lower surface of the tail marked by papillary ridges instead of being smooth, underside of tarsus haired from heel to metatarso-phalangeal joints, and white perineum and adjacent area of thighs. Comparison of our Bornean material with a series of 78 specimens from Davao, Mindanao, shows that only the heavier caudal pencil,

the haired tarsus, and the lighter color of the perineal region hold; I am unable to appreciate the "successive V-shaped sulci" on the underside of the tail that Hill mentions for *bancanus*. To these characters may be added the larger cheek teeth of *bancanus*.

These differences between the Bornean and Philippine tarsiers are slight but real, and at least for the dentition they indicate that ecological differentiation has taken place. Their evaluation is a matter of personal judgment. A case can be made out for treating the Malaysian and Philippine forms as subspecies of a single species, which would then be called *syrichta*. In my opinion, however, labelling the Malaysian and Philippine populations as distinct species, as Hill has done, better expresses the relationships, especially since some slight differentiation seems to have taken place within each of the two populations.

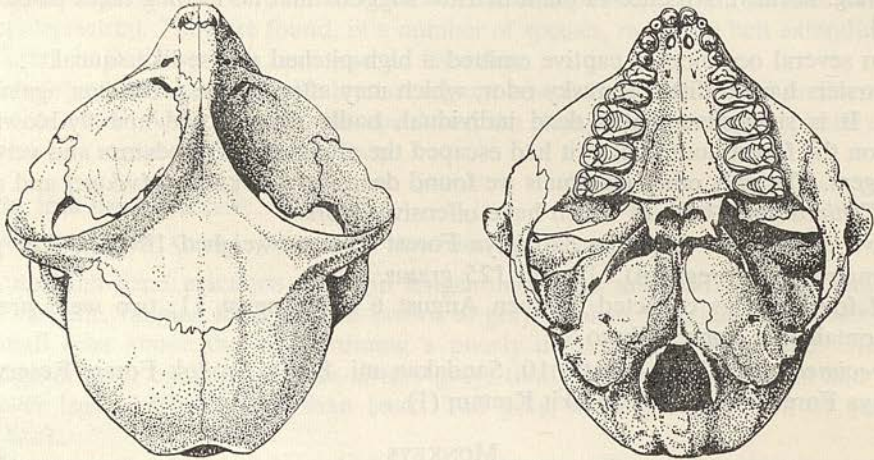


Figure 13. Skull of *Tarsius bancanus borneanus*. CNHM no. 76860, adult ♀, Sapagaya Forest Reserve. X1 1/2.

The tarsier is exclusively nocturnal, and appears to be much more common in secondary than in primary forest (Clark, 1924; Banks, 1931). Our own experience confirms this; during two months of intensive work in primary forest at Bukit Kretam not a single individual was seen, although one was found by Dyaks re-clearing an old clearing at the edge of the forest. Seven individuals were collected in one month in the Sapagaya Forest Reserve, all but one in old logged forest; these were all shot from trees, 10–20 feet from the ground, at night.

Tarsiers are arboreal, hopping from branch to branch in the trees. They also use a hopping locomotion on the ground, and appear incapable of walking by alternating movements of the legs. They often cling to a vertical stem, facing the stem and holding to it with all four feet; a captive habitually slept in this position, its head bent forward so that the face rested against the stem. In this vertical position the tail, resting against the stem, provides additional support.

These animals are astonishingly deliberate and stupid-appearing in behavior, so much so that it seems a miracle that they can survive. A captive, when offered an insect, would eye the food closely for some time, then pounce on it and hold the insect down with its fore paws. Prey is held firmly but clumsily in the fore paws while pieces are torn from it with the mouth. The eyes are closed tightly when the insect is bitten, and opened again during chewing. This animal took 25 minutes to dispose of a giant katydid about four inches long; legs, wings, and wing covers were rejected.

Stomach contents of seven individuals from the Sapagaya Forest Reserve were examined. In all but one of these the food material consisted exclusively of finely-divided insect fragments; the seventh stomach also contained the remains of a large spider. All recognizable insect fragments were orthopteroid, and relatively large orthopterans (25 mm. or more in length) certainly formed the great bulk of the food of these animals. Wings of these insects were generally absent in the stomach contents, but spiny tibias were present. No remains of ants or other small insects were found; and no fragments of wood, dead leaves, or other plant debris or detritus.

The nature of the stomach contents indicates that *Tarsius* preys upon relatively large insects⁹ exposed to view, which are recognized by sight and captured individually. Conspicuously lacking are small insects, secretive insects, and insects with hard integuments (e.g. beetles). Absence of plant detritus suggests that no feeding takes place on the ground.

On several occasions a captive emitted a high-pitched mouse-like squeak.

Tarsiers have a distinct musky odor, which may afford some protection against predators. It is suggestive that a dead individual, badly decomposed and fly-blown, was found on the forest floor, where it had escaped the attentions of predators and vertebrate scavengers. The only other mammals we found dead were a skunk (*Mydaus*) and a gymnure (*Echinorex*), both of which have offensive odors.

Two adult males from the Sapagaya Forest Reserve weighed 100 and 125 grams, two females (both pregnant) 110 and 125 grams.

Of four females collected between August 6 and August 11, two were pregnant. Each contained a single embryo.

Specimens examined.—Total 10. Sandakan mi. 8 (1); Sepilok Forest Reserve (1); Sapagaya Forest Reserve (7); Bukit Kretam (1).

MONKEYS

Family CERCOPITHECIDAE

The monkeys of North Borneo are divided between two distinct groups, the macaques and the langurs or leaf monkeys. The macaques are partly terrestrial, with a relatively short tail, a long face, well developed cheek pouches, a fairly well developed thumb, and a simple non-sacculated stomach. The langurs (including the proboscis monkey) are highly arboreal. They have long tails, short faces, no cheek pouches, a small thumb, and a large sacculated stomach. These two groups are often regarded as separate families, the macaques being grouped with the African baboons and guenons in the family Cercopithecidae, and the langurs with the African guerezas in the family Colobidae. These are here regarded as subfamilies, the Cercopithecinae and Colobinae.

KEY TO THE MONKEYS OF NORTH BORNEO

- 1 a. Tail longer than head and body 2
- b. Tail very short. General color brown above, yellowish-white below *Macacus nemestrinus nemestrinus*
- 2 a. Back yellowish-brown, sharply separated from yellowish-grey of rump and tail. Nose forming a proboscis in adult male *Nasalis larvatus larvatus*
- b. Not parti-colored yellowish-brown and yellowish-grey. No proboscis in adult male 3
- 3 a. Muzzle long and dog-like. General color brown or olive-brown above, white below *Macacus irus irus*
- b. Muzzle short, face flat. Coloration various 4

⁹. And no doubt other animals of corresponding size; captives eat lizards, small birds, and small mammals (Wharton, 1950, Jour. Mamm, 31: 266).

- 4 a. General color maroon, hands and feet mostly black *Presbytis rubicundus rubicundus*
- b. General color gray 5
- 5 a. Skin of face gray; belly gray *Presbytis cristatus ultimus*
- b. Skin of face flesh-colored with a black patch across cheek; belly white 6
- 6 a. Cheeks and temples white. A white band on forehead in males (western North Borneo)
Presbytis hosei hosei
- b. Cheeks and temples black. No white band on forehead in males (eastern North Borneo)
Presbytis hosei sabanus

Macaques

(Genus *Macacus*)

The macaques are closely related to the African baboons, but are smaller and generally less terrestrial. They are found, in a number of species, in a wide belt extending from Japan south to Bali and Java, and west to Gibraltar.

Three species occur in the Malaysian region, where two, both found in Borneo, are widely distributed. A third species (*M. speciosus*, the stump-tailed macaque), barely enters the Malaysian region in peninsular Siam.

Macacus irus irus F. Cuvier.

Crab-eating Macaque, *Kra*.

Macacus irus F. Cuvier, 1818, Mem. Mus. Hist. Nat. Paris, 4: 120.—Sumatra.

A medium-sized macaque with tail longer than head and body. The general color is very variable, ranging from reddish-brown to grayish-olive. The hairs are black-tipped in a small area above the eyes, forming a poorly defined superciliary line. Underside much lighter than back, sometimes silvery-gray; thinly haired. Lower arms and hands, and lower legs and feet, paler than back. Tail gray, lacking the reddish or yellowish of the back.

Measurements of an adult male from the Sapagaya Forest Reserve are: head and body 437, tail 588, hind foot 140. Skull measurements of the same individual are: greatest length 118.5, condylobasal length 96.5, zygomatic breadth 80, palatal length 53, upper toothrow (C-M3) 38.5. An adult female from the Kretam Besar River measured: head and body 450, tail 545, hind foot 130; skull, greatest length 121.5, condylobasal length 95, zygomatic breadth 78.5, palatal length 52, upper toothrow 37. Chasen (1940) has emphasized the extreme variability of this species, including variation with age. Only large series of fully adult individuals of both sexes would provide usable data.

Males are much heavier than females. The adult male referred to above weighed 5,250 grams; two adult females weighed 3,215 and 2,825 grams. According to Washburn (1942), males exceed females in weight by 60 per cent.

The crab-eating macaque is one of the commonest mammals of Borneo. We saw this species only in the nipa-mangrove zone, but Hose states that it is found on mountains up to 5,000 ft., and Banks (1949) says it is found "in all old jungle up to 4,000 ft." but is commonest in estuarine swamps. This monkey is common everywhere in the nipa-mangrove association in the tidal zone along the coast and the lower reaches of rivers. Along the Trusan Kinabatangan and in the Dewhurst Bay area it is associated with the proboscis monkey, and this is probably true elsewhere. The *kra* is most often seen from boats, often at a distance of only a few feet, walking about on the mud or climbing nimbly along the midribs of horizontal or nearly horizontal nipa leaves. It retreats into the nipa when alarmed. It is an expert swimmer.

The kra lives in family troops of ten or a dozen, consisting of one or two adult males, several adult females, and young of both sexes. They are noisy and quarrelsome among themselves, especially when settling down for the night. Toward sundown the troop repairs to a tall tree, usually a bare one, to sleep well up in its branches; sleeping individuals were not observed lower than about thirty feet from the ground.

There is no specific information on the food of this species in Borneo. Banks (1949) states that it eats "all fruit, rice, potatoes, leaves, crabs, prawns, but not flesh." Food is crammed into the cheek pouches, and is pushed "back into the mouth with pressure by back of hand from outside" (Banks). Macaques are very destructive to padi fields and cultivated fruit trees.

A single young is borne. Of three adult females collected between May 13 and August 9, only the one taken on August 9 was pregnant.

Specimens examined.—Bukit Kretam (1), Kretam Besar River (1), Sapagaya forest Reserve (2), Sandakan (1). Chasen and Kloss record it from Bettotan and Banguay Island, Allen and Coolidge from the Kinabatangan River and Jesselton.

Macacus nemestrinus nemestrinus Linnaeus.

Pig-tailed Macaque, *Brok*.

Simia Nemestrina Linnaeus, 1766, Syst. Nat. 12th ed., I, p. 35.—Sumatra.

Macacus nemestrinus Desmarest, 1820, Mammalogie, Part I, p. 66.

A medium-sized macaque with tail much shorter than head and body. The general color is described by Hose as "a decided olive, tending in some animals to brown." The single adult available to me, a male, is warm brown above. The crown and nape are very dark brown; and the midline of the back is darker than the sides, the dark dorsal area being continuous with the dark brown of the nape. The individual hairs are dark-tipped, with a single slightly paler annulation about 10 mm. from the tip, then becoming progressively paler toward the base. The hairs of an adult male from Sumatra are distinctly banded with five or six dark annulations. Hands and feet of the Bornean specimen are reddish brown, becoming golden on the fingers. Belly white with a faint golden wash.

Tail brown above, golden below. A subadult and a juvenile from Kalabakan are paler than the adult, but otherwise similar.¹⁰

Measurements of an adult male from Dewhurst Bay are: head and body 495, tail 180, hind foot 158; skull, greatest length 135.4, condylobasal length 107.5, zygomatic breadth 80, palatal length 61.5, upper tooththrow (C-M3) 44. These measurements are slightly smaller than Chasen and Kloss give for two males from Bettotan.

Males are much larger than females. The adult male referred to above weighed 6,925 grams. Banks (1931) gives a weight of 24 lbs. (5,040 g.) for a male and 18 lbs. (3,780 g.) for a female.

The pig-tailed macaque is less commonly seen than the crab-eating macaque. It is less partial to the nipa-mangrove zone; we have specimens from as high as 3,700 feet in the Kelabit country of northern Sarawak. Our adult male was feeding in a tree in primary forest. Its cheek pouches were filled with the fruit of an erect palm. The Kalabakan specimens were in secondary forest, about 50 feet above ground.

A single young is produced (Banks).

¹⁰. Miller (1906, Proc. U.S. Nat. Mus., 29: 558) described a specimen from the Sapagaya River as a distinct species under the name *Macaca broca*. The color of the present specimen agrees with his description, but the skull characters do not. In view of the great variability of *Macaca* I agree with Chasen and Kloss that this form should not be recognized until more material has been examined.

Specimens examined.—Dewhurst Bay (1), Kalabakan (2). Chasen and Kloss record it from Bettotan, and Allen and Coolidge from Abai on the Trusan Kinabatangan and from Mt. Kinabalu.

Leaf Monkeys
(Genus *Presbytis*)

The leaf monkeys or langurs are distributed from Assam in easternmost India, through Burma, Siam, Indo-china, the Malay Peninsula, and the East Indies. They do not reach the Philippines, and their easternmost limits are in Borneo. About ten species are recognized, each with numerous local races. Five species occur in Borneo, although only three of these are known from North Borneo. *Presbytis femoralis* and *Presbytis frontatus* have not been reported from North Borneo.

The Bornean langurs differ considerably in their body proportions (fig. 14). In the aygulus group (*P. hosei* and *P. rubicundus*) the lumbar region is long, the radius long, and the entire hind limb long¹¹. These are adaptations for leaping arboreal locomotion.

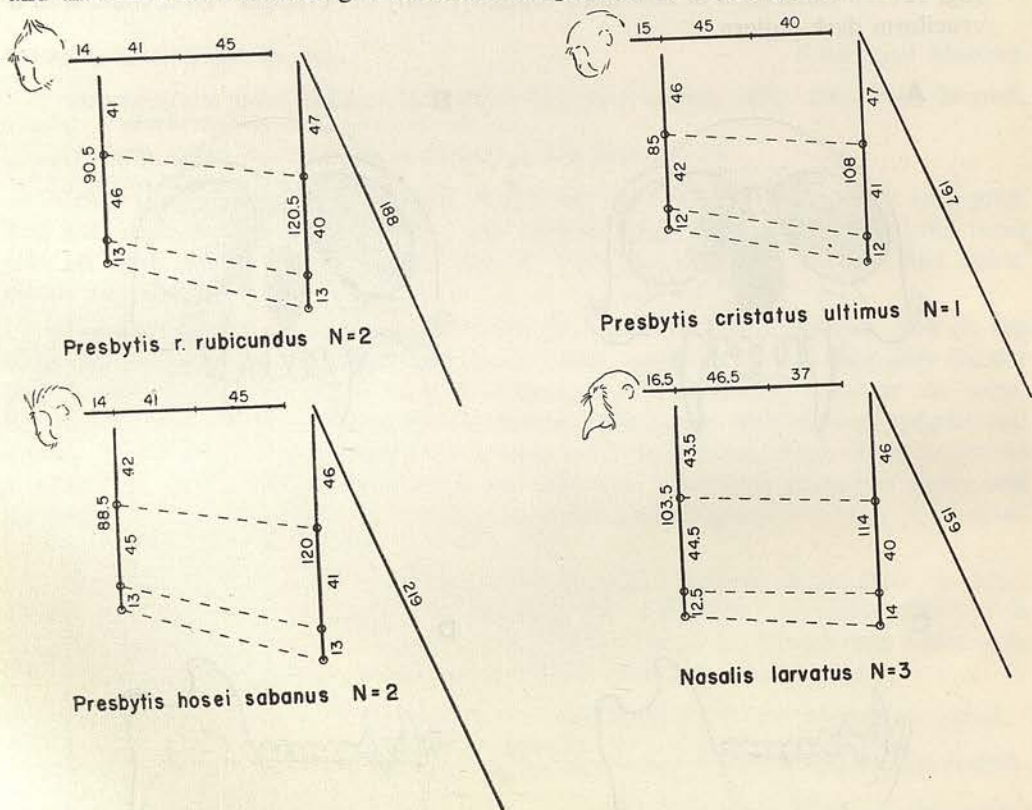


Figure 14. Body proportions in Bornean langurs. In each case the presacral spine length was equated to 100. Lengths of the cervical, thoracic, and lumbar regions, limb length and tail length are indicated as percentages of presacral spine length. Proportions of the three segments of the limb are indicated as percentages of total limb length. The dotted lines connect elbow and knee, wrist and ankle, and distal ends of third metacarpal and third metatarsal. *N* refers to number of specimens. (see text).

¹¹ All measurements were made on dried ligamentary skeletons. Limb length as used here is the "functional limb length" of Howell (1944, *Speed in Animals*, p. 198), which is the combined lengths of humerus (femur), radius (tibia), and longest metacarpal (metatarsal).

Similar adaptations are evident in the *cristatus* group (*P. cristatus*), but are much less extreme. In the proboscis monkey (*Nasalis*), in contrast, the lumbar region is not elongated and the limbs are long but subequal in length.

Pocock (1934) divided *Presbytis* into several genera, based on skull and color pattern characters. Pocock's groupings appear to be natural, although they cannot be regarded as genera and are here treated simply as species groups. Two of these species groups are represented in Borneo. They are:

1. *aygulus* group (*Presbytis* of Pocock).—Inner surface of thighs typically white, with a white stripe extending down inner side of leg. Adult male skull less constricted behind orbits, brow ridges feeble and relatively straight, nares broader and less elongate, nasal profile prominently convex (fig. 15, A). Depth of mandibular ramus from condyle to inferior border less than length of mandibular tooththrow. Mandibular ramus weaker and less extensive, with a prominent angular process (fig. 15, C). Coloration of new-born young typically of "cruciger" type, white with a cruciform dark pattern.

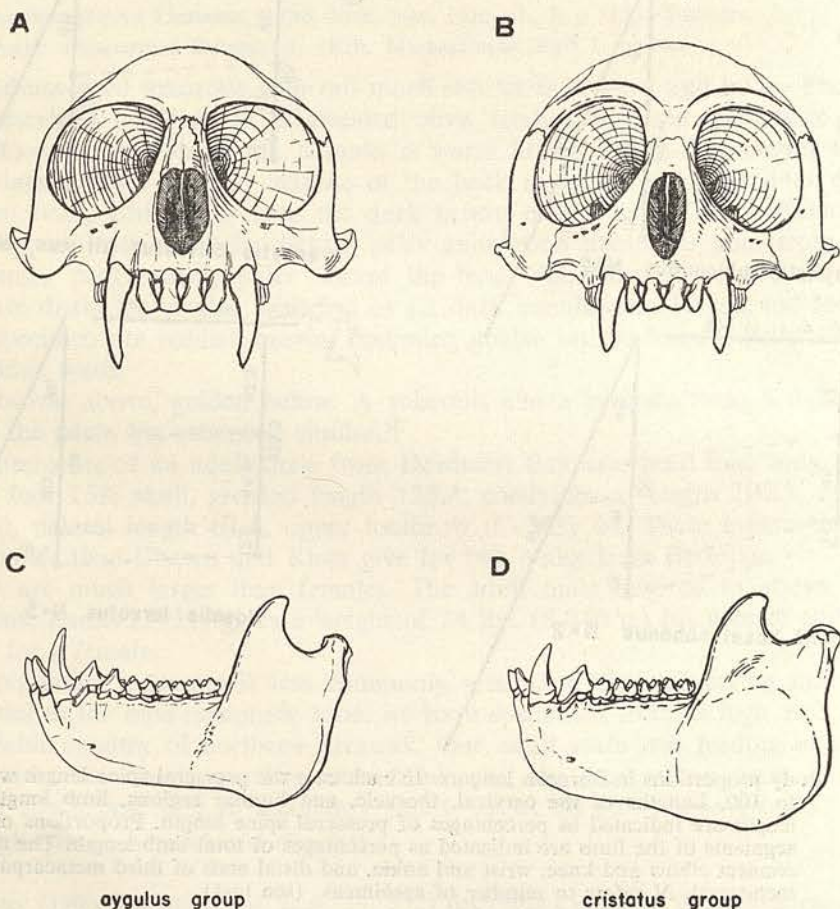


Figure 15. Anterior view of skull and lateral views of mandible to show characters of the *aygulus* and *cristatus* groups of *Presbytis*.

2. *cristatus* group (*Trachypithecus* of Pocock).—Inner surface of thighs never with the sharply-defined whiteness seen in *aygulus* group. Adult male skull moderately constricted behind orbits, brow ridges well defined and forming a V-shaped line, nares narrow, elongate and pointed inferiorly, nasal profile concave or straight (fig. 15, B). Depth of mandibular ramus from condyle to inferior border greater than length of mandibular toothrow. Mandibular ramus stronger and more extensive, without a prominent angular process (fig. 15, D). Coloration of new-born young golden red.

Aygulus Group

This group is exclusively Malaysian, ranging from peninsular Siam and Tenasserim south to Sumatra and east to Java and Borneo. Four species occur in Borneo: *melalophos* (*femoralis* of authors), *hosei* (*aygulus* of authors), *rubicundus*, and *frontatus*. Only *hosei* and *rubicundus* are known from North Borneo.

Presbytis hosei hosei Thomas.

Gray Leaf Monkey.

Semnopithecus hosei Thomas, 1892, Proc. Zool. Soc. London, 1892: 159.—Niah, Sarawak, approximately 3° 52' N, 113° 45' E.

Pithecus aygula hosei Chasen, 1940, Bull. Raffles Mus., 15: 78.

Color above, including upper side of tail and outer side of limbs, dark ashy-gray. Tail not markedly bicolor, underside only slightly paler than upper. Belly and inner sides of limbs white; white of inner sides of limbs not extending to wrist and ankle. Hands and feet black.

Hair of forehead sloping backward from the brow, forming a mat-like crest on top of the head. Long hairs of temples and cheeks white, sweeping up and back over the ear and passing to the sides of the neck, leaving only a blackish-grey band on the nape. Forehead in males wholly covered by a white band continuous with white of temples and cheeks, bordered below by a narrow black brow band. In females, originally described as a separate species (*everetti*), the white is less extensive, sometimes absent on crown and forehead. Naked area of face flesh color, except for a black patch extending from inner corner of eye to outer end of lip.

The Chicago Natural History Museum has a single specimen of this form, an adult female collected by A. H. Everett and labelled "Mt. Kinabalu," probably collected at the same time as the type of Thomas's *Semnopithecus everetti*. Chasen and Kloss state that *hosei* is a lowland form, ranging up to 3,000–4,000 feet on mountains.

Distribution.—Northern Borneo, from Mt. Kinabalu south into northern Sarawak.

Specimens examined.—Mt. Kinabalu (1). Chasen and Kloss record it from Rayoh.

Presbytis hosei sabanus Thomas.

Gray Leaf Monkey. (Plate 12).

Semnopithecus sabanus Thomas, 1893, Ann. Mag. Nat. Hist., (6) 12: 230.—Paitan, North Borneo.

Pithecus aygula sabanus Chasen, 1940, Bull. Raffles Mus., 15: 78.

Color above, including tail and outer sides of limbs, dark ashy gray. Belly and inner sides of thighs white, washed with gray on upper chest and throat. White of inner sides of limbs not extending to wrist and ankle. Hands and feet black, sharply set off.

Hair of forehead parted by a pair of whorls, with a median crest rising between them. Crest compressed and high, highest in front, becoming gradually lower over the crown and scarcely passing onto the occiput. No band of white hairs on forehead in males. Naked area of face flesh color, except for a black patch extending from inner corner of eye to outer end of upper lip. The sexes are colored alike.

Mean and extreme measurements of six adult males are: head and body 504 (480–557), tail 752 (646–840), hind foot 176 (172–185). Skulls of these specimens measure: greatest length 94.9 (91.5–98.4), basal length 66.2 (64.6–69), zygomatic breadth 72.3 (70.3–74), palatal length 35.7 (33.5–39), upper cheek teeth (C–M3) 29.2 (27.1–30.7). Weight 6,208 (6,000–6,750) grams. Measurements of an adult female are: head and body 495, tail 760, hind foot 175; skull, greatest length 92.5, basal length 65.4, upper cheek teeth 28.

Limb proportions in two adult male skeletons agree closely with the figures Washburn gives for the Maroon Leaf Monkey, and differ strikingly from his proportions for the silvered leaf monkey. The intermembral index $\frac{\text{Humerus} + \text{Radius}}{\text{Femur} + \text{Tibia}} \times 100$ is 73 for both skeletons, and the brachial index $\frac{\text{Radius}}{\text{Humerus}} \times 100$ is 107 in both. The long hind legs and long fore arms are adaptations for arboreal locomotion.

Specimens examined.—Total 8. Bukit Kretam (2), Sapagaya Forest Reserve (2), Deramakot (2), Kalabakan (2). Chasen and Kloss record it from Bettotan.

The gray leaf monkey is less abundant than the maroon leaf monkey, but at least in the vicinity of Sandakan and Dewhurst Bay it is more common than the silvered leaf monkey. According to Hose, *hosei* is found on Mt. Dulit up to 4,000 feet, and Banks says it occurs on mountains up to 3,000 feet.

Like other leaf monkeys, this species is diurnal and highly arboreal. It is usually seen in the top story of the forest, often in family parties of three although troops of a dozen or more are common. The two Kalabakan specimens were in the middle story in primary forest. When alarmed they make off through the tree tops in a series of spectacular crashing leaps. The arms and legs are spread-eagled, and the animal throws itself into the foliage without aiming at a particular branch; this is quite different from the skillful brachiation of the gibbons. According to Banks, the tail may be lashed from side to side during long leaps. The alarm call, which I noted carefully at Bukit Kretam, is a series of three or four quick guttural grunts, almost pig-like, the sequence lasting about half a second.

Nothing has been recorded of the food of the gray leaf monkey. The stomachs of *sabanus* collected by us were filled with finely ground green material, presumably leaves. A young captive male of *sabanus* kept under observation for a week was fed on milk and bananas at first, but when offered young leaves from various vines and shrubs it ate these with evident relish and they were provided daily thereafter. The leaf or branch was held in one hand and pieces torn out with the mouth. When released in dense shrubby cover it immediately retreated into the vegetation, where it was well concealed, and began eating leaves of the small tree in which it sat. This continued for half an hour, until it was removed from the tree. On the other hand, when placed in a small exposed tree in the clearing it repeatedly descended to the ground and made for the nearest cover, which was beneath the bungalow.

This monkey was very awkward in picking up or manipulating objects with its hands. After several unsuccessful attempts to pick up a leaf or a piece of banana from the floor, it almost invariably ended by leaning over and picking up the object with its mouth. Food held in the hand was grasped clumsily between the thumb and the metacarpus of the second digit.

The single adult female we collected was pregnant (May 21).

Maroon Leaf Monkeys

Jellu merah

(*Presbytis rubicundus*, Plate 13)

These are the commonest monkeys of the forest, and are found from sea-level up to several thousand feet. The species is confined to Borneo and the nearby Karimata Islands.

Maroon leaf monkeys are easily distinguished from other North Bornean monkeys by their color, which is some shade of reddish brown, varying from locality to locality. Hair on crown forming a vertical median crest confluent with the long hair of the occiput. Hair on forehead forming a radiating fringe that overhangs the eyes. Naked parts of face and ears bluish gray in life; upper lip and chin flesh color.

These, together with the closely related *P. hosei*, are the most highly specialized for arboreal leaping of the North Bornean langurs. The hind legs are long (intermembral index in two skeletons 75 and 76), and the forearm is long (humeroradial index 111, 110). The tibiofemoral index does not show any specialization for leaping, the femur in fact exceeding the tibia in length (index 90, 87).¹²

Several local races may be recognized on the basis of color. Collecting has been too spotty throughout Borneo to permit delimiting the ranges of these races, and the identity of some is still uncertain. The following forms occur in North Borneo.

Presbytis rubicundus rubicundus Müller.

Semnopithecus rubicundus Müller, 1838, Tijdschr. Nat. Gesch. Physiol., 5: 137.—Mt. Skumbang, south-east of Banjarmasin, South Borneo.

Pithecus rubicundus rubicundus Chasen, 1940, Bull. Raffles Mus., 15: 80.

Distinguished by Maroon to Mahogany Red color (Ridgeway), becoming slightly paler on underparts and inner sides of limbs. Hands and feet heavily washed with black on digits, less so on metacarpal and metatarsal areas; the hairs reddish at base tipped with black. Tail with scattered black hairs, becoming increasingly numerous toward the tail tip. Our specimens from Deramakot are indistinguishable from our material from the Sandakan Bay area.

The type locality of *rubicundus* is in the southeast corner of Borneo. Specimens from the vicinity of Sandakan agree fairly well with descriptions of the type, and Chasen and Kloss therefore identify their material from Bettotan as *rubicundus* (although they had seen no material from southeastern Borneo), and defined the range as "extending from Banjarmasin through the east of Borneo, and into the territory of British North

¹² My index figures differ slightly from those given by Washburn (1942). This is attributable to differences in the method of measuring bones; I have used the method recommended by Howell (1944).

Borneo." Gyldenstolpe had specimens from about 40 miles up the Kayan River in Indonesian East Borneo, which is only about 100 miles south of the North Borneo border. He regarded his material as "somewhat intermediate" between *rubicundus* and *ignitus* (type locality Mt. Mulu, N. Sarawak), but his description fits Sandakan specimens almost perfectly. Whether the North Bornean form is actually *rubicundus* cannot be decided on the basis of available material.

Mean and extreme measurements of four adult males from the Sandakan and Deramakot areas are: head and body 501 (440–580); tail 740 (673–800); hind foot 181 (175–185). Skull measurements of the same four individuals are: greatest length 96.4 (94–98); basal length 64.9 (63.5–66.6); zygomatic breadth 71 (69–73); palatal length 33.8 (32.3–35); upper cheek teeth (C–M³) 28.5 (28–29). Four adult females measured: head and body 501 (480–515), tail 703 (685–730), hind foot 173 (170–180). Skull, greatest length 93.0 (91–96.5), basal length 64.1 (62–65), zygomatic breadth 70.6 (68.7–72), palatal length 32.1 (32–32.5), upper cheek teeth 28.0 (27.5–28.4). An adult male weighed 6,250 grams, three non-gravid females 6,000, 6,250, and 6,500 grams. Washburn (1942) gives mean and extreme weights for 19 males of 6.2 (5.5–7.0) kilograms, of 17 females 6.0 (5.5–7.0) kilos. Thus sexual dimorphism in weight is slight, males exceeding females by about 3 percent.

Specimens examined.—Total 14. Sandakan (5), Sapagaya Forest Reserve (2), Abai (2), Deramakot (4), Kalabakan (1). Chasen and Kloss record it from Bettotan, and Allen and Coolidge from Abai and from Mt. Kinabalu.

***Presbytis rubicundus chryseus* subsp. nov.**

(Plate 13).

Type.—From area east of Kretam Kechil River, southeast end of Dewhurst Bay, Kinabatangan District, North Borneo. No. 68687 Chicago Natural History Museum. Adult female. Collected 30 May, 1950 by D. Dwight Davis. Original no. 278.

Diagnosis.—Similar to *P. r. rubicundus* but general color much paler, nearest Amber Brown (Ridgeway). The general effect is a rich reddish golden, paler on abdomen and inner sides of thighs. Digits of hands and feet buff, washed with brown. Tail washed with brown at tip.

Measurements.—Type: Head and body 500, tail 680. Skull of type: greatest length 91, basal length 64, zygomatic breadth 68, palatal length 32, upper cheek teeth (C–M³) 28.

Remarks.—A series of five specimens from the type locality, including juveniles with milk dentition, agrees closely with the type in coloration, and this material is strikingly different from series of *rubicundus* from the Sandakan Bay area, less than 50 miles away. In its light-colored feet *chryseus* resembles *ignitus* from Sarawak, but the ranges of these two forms cannot be continuous.

It appears that the colors of *P. rubicundus* are not very stable. A series of skins in the Chicago Natural History Museum labelled simply "Borneo" ranges from a pale Brussels Brown (lacking the red normally present) to Bay, which is much darker than the usual maroon color. The Brussels Brown skins lack the black on the feet. The dark pigmentation on the feet and tail tip seem to vary independently of the general body color; according to Chasen and Kloss it is completely lacking in *ignitus*, no matter how

dark the general coloration. On the other hand, *chryseus* is a pale race of *rubicundus*, with the general color and the areas of dark pigmentation both greatly reduced in intensity.

Specimens examined.—Bukit Kretam (6).

The maroon leaf monkeys live in troops ranging in size from two or three individuals to parties of eight or more. Hose speaks of troops of "some thirty or forty," but nothing approaching this size was seen by us. They are common in both primary and old logged forest, from sea level up to 6,500 feet. In primary forest they are seen in both the middle and top stories, often associated with *Presbytis hosei*.

My observations indicate that these are more shy than the gray leaf monkey. When a mixed group is alarmed, *rubicundus* makes off at once in a series of crashing leaps, while *hosei* may not flee until shot at. The alarm cry of *rubicundus*, noted carefully at Bukit Kretam, is almost bird-like, a single note repeated several times.

A single young is borne. Three adult females collected at Bukit Kretam between May 17 and June 20 were non-gravid, as were four females taken at Deramakot between April 23 and June 2. Two adult females collected in the Sapagaya Forest Reserve on August 1 and August 6 were both pregnant.

***Presbytis cristatus ultimus* Elliott.**

Silvered Leaf Monkey. (Plate 13).

Pygathrix ultima Elliott, 1910, Proc. U.S. Nat. Mus., 38: 351.—Mt. Dulit, Sarawak.

Pithecus pyrrhus ultimus Chasen 1940, Bull. Raffles Mus., 15: 83.

Color above, including tail and legs, dark gray with a very faint brownish tint, the pelage with a metallic sheen. Belly and inner side of thigh paler gray. Hands and feet black.

No crest on top of head. Brow black. Long hairs of temples gray, sweeping up and back over the ear. Naked area of face gray, without facial markings, in life. Eyelids white.

Measurements of two adult males are: head and body 415, 500; tail 600, 740, hind foot 145, 160. Skulls of these specimens are not in condition for measuring. The upper toothrow (C-M³) of the larger individual measures 32. These two specimens weighed 3,650 and 6,380 grams. The skulls of two adult males from near Jesselton (MCZ nos. 37388, 37394) measure: greatest length 101.5, 101; basal length 74.3, 72.5; palatal length 38.5, 39.5; zygomatic breadth 71.8, 71.5; upper cheek teeth 25.2, 25. According to Washburn the weight of males exceeds that of females by 16 per cent.

This species was about as common, both at Bukit Kretam and Sapagaya, as *Presbytis hosei sabanus*. On the other hand, Schultz and Washburn collected 58 specimens of *P. c. ultimus* and only one female and infant of *P. h. sabanus* at Abai, about midway between our two localities (Allen and Coolidge). The Abai population of *P. c. ultimus* contained an erythristic mutant, orange-cinnamon in color, that made up 24 per cent of the sample collected by Schultz and Washburn.

Gibson-Hill (1949) listed the calls of *Presbytis cristatus* as recorded at Kuala Selangor. These were four in number: "a grunt of annoyance," a somewhat donkey-like bray, "a little questioning click," and "a prolonged thin highpitched squeak." The significance of these various calls is unknown.

Specimens examined.—Bukit Kretam (1), Sapagaya Forest Reserve (1), near Jesselton (2). Allen and Coolidge record it (as *Trachypithecus pyrrhus cristatus*) from Abai and from near Jesselton.

Nasalis larvatus van Wurm.

Proboscis Monkey. (Plates 14, 15).

Cercopithecus (sic) *larvatus* van Wurm, 1781, Verh. Batav. Genootsch., 3: 353.—Pontianak, West Borneo.

Nasalis larvatus Geoffroy, 1812, Ann. Mus., 19: 90.

The proboscis monkey can scarcely be confused with any other Bornean monkey. Its large size, the extraordinary development of the nose, and the conspicuous color pattern distinguish it from all other Bornean langurs. *Nasalis* is a monotypic genus confined to Borneo. Its closest living relatives are the remarkable snub-nosed monkeys (*Rhinopithecus*) of western China, Tonkin, and the Mentawi Islands, Western Sumatra.

Colors are somewhat variable. The shoulders and upper back are yellowish brown to reddish brown, almost maroon in some individuals. Only the tips of the hairs are so colored, the proximal two-thirds being gray, and this gives a grizzled appearance to the pelage that increases as the pelage wears. Lower back and tail yellowish white or grayish white, forming a lumbar patch sharply set off from color of back and thighs. Tail sometimes, but not always, darker above than below. Belly yellowish or grayish, sometimes washed with rufous. Legs and feet yellowish to yellowish-white, usually distinctly grizzled. A reddish-brown cap, sharply set off, on top of head, continued as a narrow nuchal stripe onto shoulders. Throat and sides of neck cream color, sometimes washed with rufous. Naked parts of face, including nose, are approximately Hazel (Ridgeway) in recently tanned skins. In the foot the second and third toes are often webbed to the middle of the middle phalanx of digit II (Plate 15), and the webbing may reach the end of the middle phalanx (Schultz, 1942).

Mean and extreme measurements of four adult males are: head and body 601 (555–651), tail 719 (674–745), hind foot 218 (210–225). Skull measurements of the same individuals are: greatest length 127.6 (125–133), basal length 94.3 (91.5–99.5), zygomatic breadth 85.3 (80–90), palatal length 47.6 (46–50.7), upper cheek teeth (C–M³) 39.9 (38–42.4). These four animals weighed 11.7, 14, 16, and 20 kilograms (25.8, 30.9, 35.5, and 44 pounds). Allen and Coolidge record a male that weighed 52 pounds, and Schultz gives the mean weight of ten adult males as 20.3 kilograms (45 pounds).

Measurements of a female from near Sandakan and another from Kalabakan are: head and body 550, 555; tail 620, 570; hind foot 190, 193. Skull greatest length 109, 107; basal length 77.8, 78.3; zygomatic breadth 71, 73.2; palatal length 39.6, 38.7; upper cheek teeth 36, 35.8. The Kalabakan female weighed 10.5 kg. (23 pounds), and Schultz (1942) gives the mean weight of fifteen adult females as 9.9 kg. (22 pounds). Thus males are twice as heavy as females, a sex difference that is equalled among cercopithecids only in some baboons.

Chasen (1940) attempted to divide the proboscis monkeys into two races, naming a subspecies (*orientalis*) from Salim Batu, Bulungan, Dutch Northeast Borneo. This is about 175 miles south of the area from which our material came. The characters given—cap less sharply defined, nuchal stripe obsolete, upper parts paler and more uniform, underparts more deeply and uniformly ferruginous—are not evident in North Bornean specimens. Much more material is required before races of this monkey can be recognised.

The proboscis monkey is common in the nipa-mangrove association along the coast and the lower reaches of rivers, where it is associated with the crab-eating macaque. In the late afternoon troops up to 20 in number are seen, often high in the trees where they are silhouetted against the sky. When alarmed they either retreat into the nipa or

make off through the trees in the crashing leaps characteristic of langurs. Big males are evidently too heavy for such locomotion, and they were observed to climb carefully through the trees in striking contrast to the headlong flight of lighter members of the troop. Accidents appear to be common; healed bone fractures were present in 28 per cent of 25 adult skeletons examined by Schultz.

The clouded leopard is known to capture and feed on adult proboscis monkeys (see record on p. 117).

The proboscis monkey is not strictly confined to the nipa-mangrove association. On several occasions individuals were heard in forest farther upstream than the nipa-mangrove zone, but they were never encountered any great distance from river banks. In May 1956 three separate troops were observed on the Kinabatangan above Bilit, at least 30 miles upstream from the nipa-mangrove zone. This monkey swims well, using a powerful dog paddle, with the head carried well out of the water. An adult male was captured swimming across the mouth of the Sapagaya River, where the river is a quarter of a mile or more wide. When the boat was nearly alongside this animal he dived and remained submerged so long we began to suspect something had happened to him. This individual was astonishingly docile, showing no inclination to fight and making little effort to escape after being brought aboard the boat.

The external nose in adult males is an enormously enlarged bulbous structure with the nostrils inferior (Plate 14). It cannot be inflated, but it moves considerably with movements of the mouth. In females and juveniles of both sexes the nose is snubbed upward but is of normal size; in the new-born young it is deep blue in color (Schultz 1942). The significance of the enlarged nose in the male is unknown and has been the subject of much speculation. I suggest that it has no functional significance, but merely reflects the result of an exponential growth rate. It may be postulated that the morphogenetic mechanism producing the original snub nose involves a differential growth rate, with the nose growing at a faster rate than the body as a whole. The form ancestral to *Nasalis* was probably a snub-nosed species in which the males exceeded the females only slightly in body size, as is typical for langurs. If, then, the total size of the male increased greatly in the course of evolution (as indeed appears to be the case), the size of the nose would increase at a still faster rate and the grotesque structure now seen in adult males would result. Such a structure need have no functional significance, since natural selection would have operated on body size and not on nose size. This, of course, does not explain the significance of the original snub nose, which occurs in several genera of monkeys.

The voice of the male is a deep snoring honk, very similar to the call of the American bullfrog. The voice of the female is similar but less deep and resonant.

The food is apparently largely the young leaves and growing tips of mangrove and pedada (*Sonneratia*) trees. The stomachs of our specimens were filled with finely ground material the color and consistency of mustard. During feeding the animal sits in a crotch or on a horizontal branch and reaches out with one hand, usually holding on with the other.

A single young is produced (Banks, Schultz).

Specimens examined.—Total 6. Trusan of Kinabatangan River (2), mouth of Sapagaya River (1), near Sandakan (1), Kalabakan (2). Allen and Coolidge record it from Abai.

GIBBONS

Family HYLOBATIDAE

Only one species of gibbon (*moloch*) occurs in Borneo. Outside of Borneo this species occurs only on Java. The gibbon exhibits much geographic variation in Borneo, and four races, based on color differences, are usually recognized (Kloss, 1929). The range of *H. m. funereus* coincides fairly closely with the limits of the colony of North Borneo.

Hylobates moloch funereus Geoffroy. North Bornean Gibbon, *Wa-wa*. (Plate 16).

Hylobates funereus Is. Geoffroy, 1850, Compt. Rend. Acad. Sci. Paris, 31: 874.—Island of Sulu (= Jolo?) (introduced).

Hylobates moloch funereus Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 2.

The North Bornean gibbon is distinguished from other Bornean subspecies by the combination of very dark underparts associated with light-colored hands and feet. The colors of *funereus* are quite variable, although the pattern is uniform. The back, including the outer sides of the arms and legs, is pale, varying from pale grayish brown to buffy brown. The color of the hands is similar to the outer side of the forearm, but the feet and ankles are paler than the lower leg. Throat, belly, and inner sides of upper arm very dark brown or black; inner sides of thighs dark brown. Inner side of forearm darker than outer; inner side of lower leg slightly or not at all darker than outer.

Head with a dark brown cap. In front of this there is a light brow-patch, varying from a small patch above the eyes to a ring completely encircling the face. Eyebrows and naked skin of face and ears black. A small patch of dark brown or black hairs around the genitalia.

Two adult males measured: head and body 420, 450; hind foot 128, 150. Skull, greatest length 97.5, 105.5; basal length 72, 77; zygomatic breadth 69, 71; palatal length 41, 44; upper toothrow (C-M³) 33 (M³ unerupted in larger specimen). Mean and extreme measurements of five adult females are: head and body 442 (432–470), hind foot 134 (130–140); skull, greatest length 99.1 (95–101), basal length 70.0 (66.2–73.5), zygomatic breadth 66.1 (62–68.5), palatal length 37.8 (36–40), upper cheek teeth 29.8 (28–31.9).

Two adult males weighed 5,095 and 6,400 grams (11 and 14 pounds), and four non-pregnant females 4,110, 4,500, 5,025, and 5,285 grams.

Gibbons are diurnal and among the most conspicuous inhabitants of the North Bornean forest, and their beautiful morning calls are heard wherever there is old forest. They live in small family groups; in four instances where it was possible to count all individuals the party consisted of three—an adult male, and adult female, and an immature. Larger groups undoubtedly occur where the family group includes several young of different ages, as Carpenter (1940) found for *Hylobates lar* in Siam.

Gibbons are usually seen in the top story of the forest, more rarely in the middle story. They are often associated with leaf monkeys. The spectacular, graceful locomotion of these animals is predominantly brachiation by means of the hands and arms alone; less often they walk along horizontal or near-horizontal branches using the legs alone, or climb vertical trunks using both arms and legs. The brachiation of gibbons is far more skillful than the reckless crashing leaps of leaf monkeys. It requires judgment, coordination, and a very short visual-motor reaction time. When alarmed they

may use the crashing tactics; I saw an alarmed individual make a vertical drop of an estimated 30 feet into the crown of a smaller tree, its arms flailing the air during the descent.

The call of the gibbon is indescribable, though the native name, wa-wa, is based on it. The call is a sequence of about 20 loud musical hoots in rapidly increasing succession, ending in a rolling warble. It can be heard a mile or more through the forest. The calls are heard regularly from dawn to about 8:00 a.m. Occasionally an individual was heard calling in the late morning, between 10:30 and 11:30 a.m.

Food "seems to consist of fruits, shoots and young leaves" (Banks). In the area in which we worked, the fruits of large fig trees (*Ficus* sp.) seem to be an important element in the diet; family groups were observed feeding in these trees on several occasions. Carpenter found that various species of *Ficus* form the most important article of diet of *Hylobates lar* in Siam. He estimated that fruits form about 80 per cent of the diet, the remaining 20 per cent consisting largely of leaves, buds, and flowers, but also including birds' eggs, young birds, and insects.

Carpenter, in his intensive study of *Hylobates lar*, found that this species exhibits territoriality, and that each group defends its territory by actual fighting and by vocalization. He estimated population density at 10 or 12 individuals in two or three groups per square mile. It is reasonable to assume that a similar situation exists in *Hylobates moloch*, but there are no data for the Bornean species.

A single young is produced. Of five adult females collected between 11 May and 19 June two (28 May, June 6) were pregnant and two were accompanied by unweaned young. The young cling to the belly of the mother until able to shift for themselves, and must remain in the family party for several years. An infant we had in camp for several weeks was content to be carried about clinging to the thigh of a man, face inward and holding on tightly with all four limbs.

Specimens examined.—Total 12. Bukit Kretam (7), Sandakan mi. 5 (1), Sandakan mi. 8 (3), Kalabakan (1). Chasen and Kloss record it from Bettotan and Rayoh, and Allen and Coolidge from Abai and Mt. Kinabalu (5,000 feet).

ORANG UTAN

Family PONGIDAE

There has been much discussion as to whether the Bornean orang is distinguishable from the Sumatran orang. Lyon (1911), after examining the material in the U.S. National Museum, separated them although "it is with great difficulty that I have been able to find any tangible differences." He was followed by Chasen in the *Handlist*. Other workers have proposed many additional subspecies. The data are obviously flimsy and of debatable significance, and this impresses me as a singularly sterile argument. If the two forms are split, the Bornean form becomes *P. p. pygmaeus*, the Sumatran form *P. p. abelii*.

Pongo pygmaeus Linnaeus.

Orang Utan, *Mias*.

Simia pygmaeus Linnaeus, 1766, *Anthropomorpha* (Upsaliae), p. 6.—"Habitat in Africa," error, Borneo or Sumatra.

Pongo pygmaeus Rothschild, 1904, *Proc. Zool. Soc. London*, 1904 (2): 436.

Simia satyrus Chasen, 1940, *Bull. Raffles Mus.*, 15: 60.

The orang utan is still fairly common, at least in areas near the coast, in eastern North Borneo. It is impossible to estimate the number of individuals in an area, because orangs do not flee in the presence of man and a quiet individual in a tree is remarkably

difficult to see. Most oranges are discovered by accident, unless they happen to be spotted while moving through an opening in the foliage. Only one wild individual was seen by us, along the Gaja River in the Bukit Kretam area, but this is no indication of their actual numbers. The skulls of two large males, killed by others during our stay, were preserved, and the Game Warden in Sandakan had in his custody three youngsters that had been confiscated. In 1928 F. C. Wonder collected an entire family group of five individuals at mile 8 northwest of Sandakan, and the Harvard Primate Expedition collected seven at Abai from June to August, 1937.

Orangs seem to be confined to the primary forest. They live in the smaller trees of the middle story, and are not seen in the forest canopy. The natives in eastern North Borneo believe that aged oranges are unable to climb, and take up residence between the buttresses of large trees. From here they are believed to rush out on unwary passersby, and people are therefore very reluctant to pass close to a large-buttressed tree.

The movements of the orang are very slow and deliberate, in striking contrast with the gibbon and the langurs with which it is associated. In part, at least, this is a function of size and weight; it would be impossible for an animal as heavy as an orang to move through the trees with the long leaps and spectacular crash landings of the smaller primates.

The animals collected by Wonder were feeding on the fruit of a mango (*Mangifera* sp.). A piece of the husk was torn off with the teeth, and the pulp then removed from the interior by inserting a finger into the hole. The best general account of the biology of the orang is still the vivid descriptions written by Hornaday (1885).

Measurements of the adults in the Chicago Natural History Museum are given in the following table, together with measurements given by Chasen (1923) of a very large male from Indonesian West Borneo and by Lyon (1911) of his largest male, from the Semandang River in southwestern Indonesian Borneo.

		Skull Basal Length	Zygomatic Width	Mastoid Width	Upper Toothrow	Crown to Heel	Reach
33535 ♂	...	163	156	132	75	—	2187
	Sandakan mi. 8						(7 ft. 2 in.)
68672 (♂)	...	158	157	143	68	—	—
	Gomantong Forest Res.						
68673 (♂)	...	165	158	138	71.5	—	—
	Segaliud River						
Chasen 1923 ♂	...	168	164	135	68	1412	2440
						(4 ft. 7 1/2 in.)	(8 ft.)
Lyon 1911 ¹³ ♂	...	168	173	147	70	1410	—

Specimens examined.—Sandakan mi. 8 (5), Gomantong Forest Reserve (1 skull), Segaliud River 18 mi. from mouth (1 skull). Allen and Coolidge record it from Abai.

¹³. Lyon gives the weight of this and one other (fat) male as 200 kilos. This is 440 pounds, which of course is fantastic. He states that he used "collector's measurements in pounds and quarters computed to kilograms," and obviously made a gross error in calculation. Yerkes and Yerkes (1929, *The Great Apes*, p. 104), after a careful search of the literature, give 120–160 pounds as the weight of a mature male.

PHOLIDOTA

SCALY ANTEATERS

Family MANIDAE

Manis javanica Desmarest. Malaysian Scaly Anteater, *Tengiling*. (Plate 17).

Manis javanica Desmarest, 1822. Ency. Méth. (Mamm.), II: 377.—Java.

Paramanis javanica Pocock, 1924, Proc. Zool. Soc. London, 1924: 722.

Manis javanica Chasen, 1940, Bull. Raffles Mus., 15: 111.

This species is widely distributed throughout the Malaysian Subregion. On Palawan and the Calamianes it is replaced by a distinctive species, *M. culionensis*.

The large scales completely encircle the tail to its base, but on the head, body, and limbs they are present on the top and sides only. In North Bornean specimens there are 28 or 29 scales in the median line on head and body, and 28 or 29 on the tail. There are 13 scales in a diagonal row around the body. Scales rounded, with longitudinal striae on basal two thirds, smooth at tip; lowermost four rows with a prominent median keel. Scales dark brown dorsally and on outer sides of legs, light horn-color on sides of body and underside of tail. In one specimen the distal half of the tail is light above, while in the second specimen only the distal sixth is so marked. A naked cutaneous pad on the underside of the tail tip. Skin of throat and belly flesh-color, sparsely clothed with short white hairs.

Measurements of two adult males from near Sandakan are: head and body 455, 500; tail 395, 420; hind foot 61, 97. Skulls of these two individuals measure: total length 88, 95; greatest width 35, 36.5. Lyon (1908) mentions an old male from Pontianak in western Indonesian Borneo that weighed 7,480 grams (16½ pounds).

The Malaysian scaly anteater is arboreal and nocturnal. It is not confined to old forest; individuals captured in cultivated areas near Sandakan are often brought in to the market by Chinese. Hose (1893) states that this species occurs at altitudes up to 3,000 feet on Mt. Dulit.

According to Banks they usually make for trees when pursued. Two captives observed by me were expert climbers, climbing vertical trunks by the caterpillar method of locomotion used by many arboreal mammals: the fore feet embrace the tree, then the hind feet are brought up together, embrace the tree, and the fore feet move up for a new hold. The long tail is prehensile, and is capable of sustaining the weight of the animal for a time.

When disturbed the scaly anteater rolls into a ball, with the soft underbelly on the inside and the hind feet gripping the scales over the neck. It is extremely difficult to unroll the animal from this position.

The food is presumably termites and ants. A single young is borne (Banks).

Specimens examined.—Sandakan area (2), Sandakan mi. 8 (1). Chasen and Kloss record it from Bettotan.

RODENTIA

About a third of the known species of lowland mammals of North Borneo are rodents. Only three families are represented: the Sciuridae (squirrels), the Muridae (Old World rats), and the Hystricidae (porcupines). The Spalacidae (bamboo rats) are not found in Borneo but are represented in the Malay Peninsula and in Sumatra.

The cosmopolitan Lagomorpha (hares and rabbits), formerly classified with the Rodentia, are also absent from Borneo although they occur in Sumatra and Java.

SQUIRRELS

Family SCIURIDAE

Squirrels are the commonest mammals seen in the forest. Both arboreal and ground-living forms are present, but Bornean squirrels are predominantly arboreal. The largest (*Ratufa*) and smallest (*Nannosciurus*) of living tree squirrels are represented.

Of non-flying squirrels, 10 genera and 19 species are known from Borneo. Nine genera and 14 species have been recorded from North Borneo; four of these (*Nannosciurus whiteheadi*, *Dremomys everetti*, *Sundasciurus jentinki*, and *Glyphotes simus*) are known only from Mt. Kinabalu. The genus *Lariscus* has been reported from Sarawak but has not yet been found in North Borneo.

The genera of Oriental squirrels are based partly on the structure of the baculum, following Thomas (1915). Chasen (1940) and Ellerman (1940: 266), for reasons that seem illogical to me, refused to follow Thomas and lumped *Tomeutes* [= *Sundasciurus* of the present report; see Moore 1958] into *Callosciurus* (Ellerman), or even lumped both *Tomeutes* and *Callosciurus* into *Sciurus* (Chasen). The baculum is distinctive in these two genera (fig. 16), and the characters are consistent in all species of each genus that have been examined. No doubt careful study of the soft parts of the male reproductive organs will reveal differences even more striking. Moore (1958) has used the structure of the auditory bulla to separate these two genera.

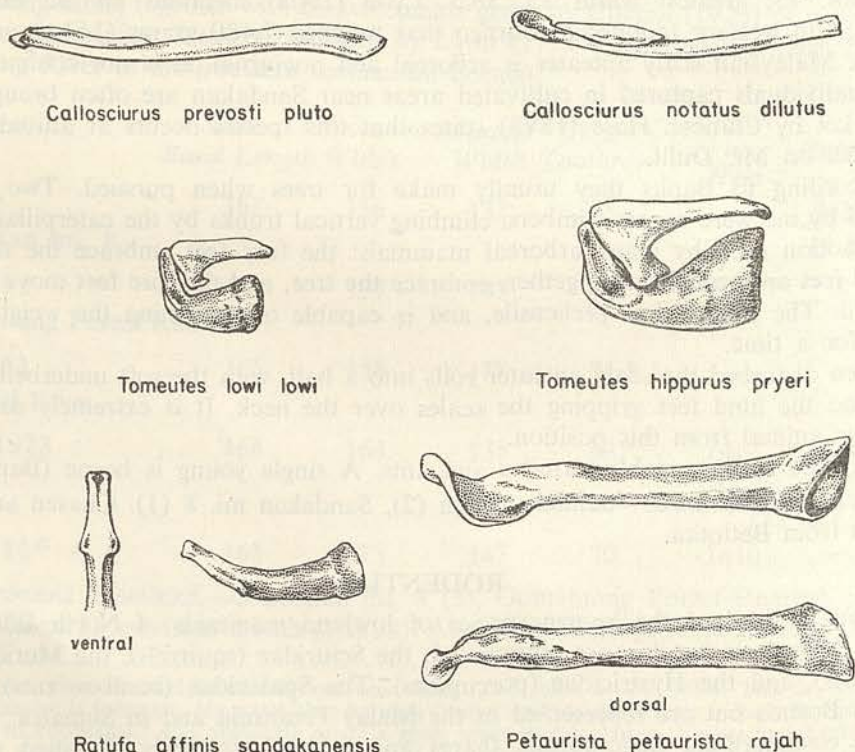


Figure 16. Bacula of North Bornean squirrels, all seen from the left side except as noted. X 1.

Our data on the food habits of five of the 10 species of lowland tree squirrels, derived from analysis of stomach contents, indicates significant differences in diet among squirrels with very similar teeth and jaws. *Ratufa* seems to be exclusively herbivorous and *Sundasciurus hippurus* essentially so, but *Ratufa* includes leaves in its diet whereas *S. hippurus* does not. *Callosciurus prevosti pluto* appears to be essentially herbivorous, but includes a small percentage of arthropods in its diet. *Sundasciurus lowi* is much more carnivorous, about half its food consisting of arthropods. *Nannosciurus exilis* is essentially a vegetarian, but also eats a significant quantity of ants. Unfortunately the diet is completely unknown for *Rheithrosciurus*, and also for *Rhinosciurus*, the squirrels with the most aberrant teeth and jaws.

KEY TO THE TREE SQUIRRELS OF NORTH BORNEO

- 1 a. Size medium to large; head and body more than 130 mm. 2
 b. Size very small; head and body less than 75 mm. *Nannosciurus exilis*
- 2 a. Size large; head and body more than 300 mm. 3
 b. Size medium; head and body more than 130 mm. 4
- 3 a. Ears conspicuously tufted; tail very bushy *Rheithrosciurus macrotis*
 b. Ears without tufts; tail long and round in cross section *Ratufa affinis sandakanensis*
- 4 a. Belly red; back or sides of body with one or more pairs of longitudinal stripes (sometimes very faint) 5
 b. Belly white, cream, or lightly washed with red; no stripes on back or sides 8
- 5 a. Back with seven well-defined variously colored stripes *Paralariscus hosei*
 b. Back unstriped, lower half of side with a pale stripe bordered beneath with black 6
- 6 a. Color intense black above, red beneath *Callosciurus prevosti pluto*
 b. Color olive-brown above, reddish beneath 7
- 7 a. A buff-colored patch behind ear *Callosciurus albescens adamsi*
 b. No buff-colored patch behind ear *Callosciurus notatus dilutus*
- 8 a. Head and body less than 155 mm. *Sundasciurus l. lowi*
 b. Head and body more than 175 mm. 9
- 9 a. Head and tail gray, rump rufous *Sundasciurus hippurus pryori*
 b. Upper parts uniformly reddish-brown; nose very long *Rhinosciurus l. laticaudatus*

Ratufa affinis sandakanensis Bonhote.

Giant Squirrel

Ratufa ephippium sandakanensis Bonhote, 1900, Ann. Mag. Nat. Hist. (7) 5: 497.—Sandakan, North Borneo.

Ratufa affinis sandakanensis Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 20.

The giant squirrel is so distinctive in appearance that it is unlikely to be confused with any other squirrel. The only other Bornean squirrel that equals it in size is the equally distinctive tufted ground squirrel (*Rheithrosciurus*). Chasen and Kloss (1931) recognized four subspecies of *Ratufa affinis* in Borneo: *sandakanensis* in North Borneo, *baramensis* in Sarawak and Indonesian North-east Borneo; *cothurnata* in south-west Borneo, and *ephippium* in South-east Borneo. These are based on average color differences; there is much individual color variation in *Ratufa affinis*, and numerous names have been proposed on the basis of individual variants.

The species *affinis* occurs in the Malay Peninsula, Sumatra, Borneo, and the islands of the Karimata Strait and the South China Sea; it is absent on Java and Bali.

In *R. a. sandakanensis* the crown, nape, and back are very dark brown, almost black. The width of the dark area varies from a narrow median line to a wide area including all of the back and flanks. In some individuals there is a considerable reddish suffusion. Muzzle grizzled with reddish buff; cheeks rufous; sides of body and outer sides of arms and thighs grizzled with buff; belly and inner sides of legs cream color, sharply separated from darker upper parts, with a reddish suffusion on the throat. Hands and feet cream color. Tail bushy, dark brown above grizzled with buff, the grizzling tending to form narrow annular rings; underside of tail cream color except at tip. Fore and hind feet very broad, with very large pads and short sharply-curved claws. A specimen from Paitan, in northern North Borneo, is more reddish than any specimen from eastern North Borneo, and is in fact almost exactly intermediate between these and specimens of *baramensis* available to me. Mammae, 3 pairs.

Mean and extreme head and body lengths of six adults from Sapagaya Forest Reserve and Bukit Kretam are 328 (320–335), tail 418 (395–440), hind foot 81.5 (79–86). Skull measurements of 13 adults of both sexes from eastern North Borneo are: greatest length 66.2 (63.7–69.7), condylobasal length $61.1 \pm .35$ (59–64), zygomatic breadth 41.1 (39.5–42.8), palatal length 30.0 (29–31), interorbital constriction 26.9 (21.4–28.6), upper cheek teeth 13.3 (12.5–13.8). Mean and extreme weights of twelve adults were 1,082 (875–1,500) grams; there appears to be no difference between the sexes in weight. Allen and Coolidge give weights of 3 and 3.5 pounds for two females.

In North Borneo the giant squirrel is quite abundant, but appears to be confined to tall heavy forest. All individuals seen by us were in primary or old logged forest. It is diurnal. Griswold (in Allen and Coolidge 1940) collected it at 4,000 feet on Kinabalu, asserting that it certainly does not occur much above that altitude and is uncommon on Kinabalu. All individuals I saw were in the crowns of the large trees, in the top story of the forest. They occurred singly except on one occasion, when a pair (male and female) was shot feeding in the same tree. Motley and Dillwyn (1885) state that they saw "as many as 20 together feeding in the same tree" on Labuan.

This species always carries the long tail pendant, never curled over the back. It often sits crosswise on a branch, the long tail hanging down. *Ratufa* is a skillful climber, as its highly modified feet would suggest, moving rapidly through the canopy when alarmed. (Griswold regarded it as "quite slow for a squirrel.")

We never heard one emit a sound. Motley and Dillwyn state that "the usual note is a harsh loud chatter, each single note being separated by a longer interval toward the close." They also describe "a sort of often repeated croak, which seemed to shake its whole frame, and gave the tail a peculiar swinging motion." Griswold described a clucking noise that can be heard at some distance. Banks speaks of a captive that "after a lot of chuckling gave vent to a clear string of loud rather bird-like whistles."

The food of *Ratufa affinis* is unknown. Most of those seen by us were in large fig trees, feeding. Stomach contents of four individuals from Bukit Kretam and the Sapagaya Forest Reserve were examined. The bulk of the food consists of finely-divided pieces of plant material, apparently fruits and nuts. Fragments of green leaves, including pieces up to 5–10 mm. in diameter, are numerous. None of the stomachs contained any animal remains. One well-filled stomach held 230 cc. (nearly half a pint) of food.

The nest, according to Banks, is "a huge affair high and far out along a branch . . . a number of large sticks are very loosely set in the fork of a tree and the inside lined with some fine brownish fibers, the entrance opening downward." Of eight females

collected between 22 April and 11 August two were pregnant (June 15, June 17), and one taken 7 August was lactating. Motley and Dillwyn state that a pregnant female contained three young.

Specimens examined.—Total 16. Bukit Kretam (3), Sapagaya Forest Reserve (3), Sandakan mi. 8 (1), Paitan (1), Deramakot (3), Kalabakan (5). Chasen and Kloss record it from the Samawang River, Bettotan, and Rayoh; Motley and Dillwyn from Labuan; and Allen and Coolidge from Mt. Kinabalu 4,000 feet.

***Rheithrosciurus macrotis* Gray.**

Tufted Ground Squirrel.

Sciurus macrotis Gray, 1856, Proc. Zool. Soc. London, 1856: 341.—Sarawak.

Rheithrosciurus macrotis Gray, 1867, Ann. Mag. Nat. Hist. (3) 20: 273.

This remarkable squirrel is easily recognized by its large size and the enormous tufts of dark hairs on the tips of the ears. Head and body dark brown faintly grizzled with olive, becoming chestnut on the lower back and thighs. Belly, throat, and inner sides of fore legs gray or pale buff. A buff-colored lateral stripe on the side of the body, extending from axilla to groin, bordered below by a very dark brown stripe sharply separated from the pale belly. Tail very bushy, the hairs dark but with long buff tips that give the tail a grizzled appearance. In the skull the rostrum is compressed, the incisors narrow transversely but deep anteroposteriorly, and the cheek teeth are considerably reduced (fig. 17). Mammæ, 4 pairs.

Collector's measurements of an adult male from the Kalabakan River are: head and body 335, tail 328, hind foot 84. Gyldenstolpe (1919) gives the measurements of two males from the Kayan River in Indonesian East Borneo about 100 miles south of the North Borneo border, as: head and body 349, 337; tail 299, 321; hind foot 84, 81. Skull measurements of the Kalabakan specimen are: greatest length 81, condylobasal length 75, zygomatic breadth 46.5, palatal length 45, upper cheek teeth 12.6.

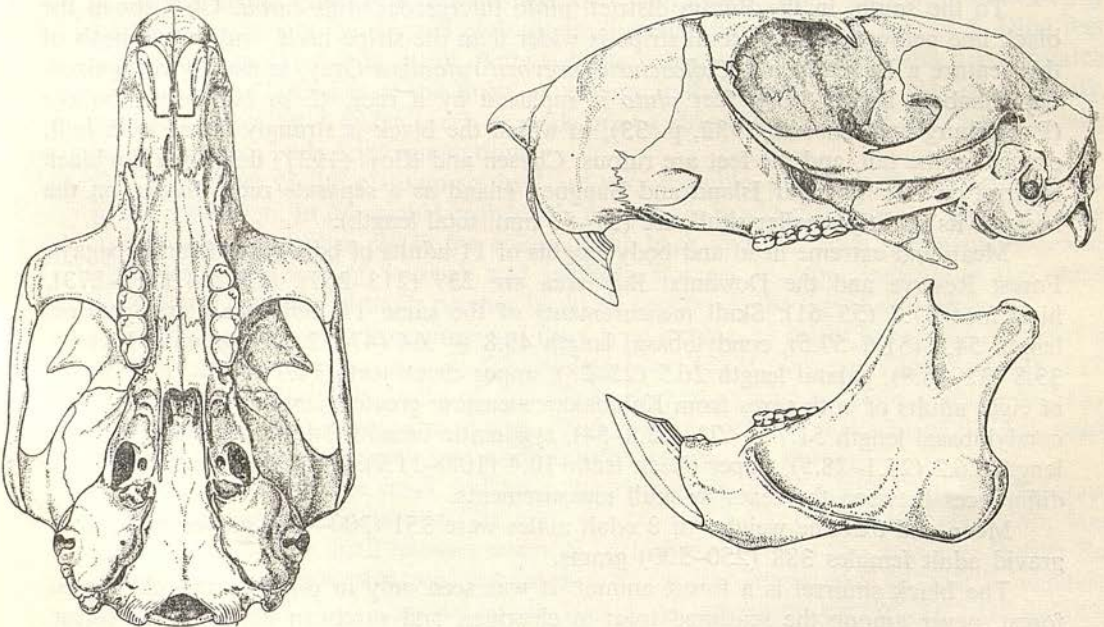


Figure 17. Skull of *Rheithrosciurus macrotis*. MCZ no. 35660, adult ♂, Kalabakan. X 1.

Rheithrosciurus, containing the single species *macrotis*, is one of the few mammalian genera confined to Borneo, and seems to be rare. The relationships of this remarkable squirrel are unknown. Moore (1961) believed the presence of two septa in the auditory bulla and of four pairs of mammae ally it to the Holarctic *Sciurus*, but much more evidence is needed before so improbable a relationship can be accepted.

Little has been recorded of the habits of the tufted ground squirrel. According to Hose (1893) it is a lowland form, ascending mountains to about 2,000 feet; the Chicago Natural History Museum has a specimen from Bario, on the Kelabit Plateau, above 3,500 feet. It is a ground-dwelling form, although Banks states that "it is at times an arboreal animal." The same author says an individual "was observed feeding on some fruits that had fallen to the ground."

Specimens examined.—Kalabakan (1) (MCZ no. 35660).

***Callosciurus prevosti pluto* Gray.**

Black Squirrel.

Macroxys pluto Gray, 1867, Ann. Mag. Nat. Hist., 20: 283.—Sarawak (more probably from North Borneo).

Callosciurus prevosti pluto Gyldenstolpe, 1919, K. Svenska Vet.-akad. Handlingar, 60 (6): 35.

Sciurus prevostii pluto Chasen, 1940, Bull. Raffles Mus., 15: 131.

Upper sides of head and body, cheeks, outer sides of fore and hind legs, and entire tail black. Belly, throat, and inner sides of limbs chestnut. There is a faint gray lateral stripe, sometimes almost indistinguishable, on the sides, separated from the chestnut of the belly by a narrow black line no wider than the light stripe. In southwestern North Borneo (Rayoh) the head tends to be grizzled and the lateral stripe lighter and broader (Chasen and Kloss, 1931). In general, in contrast with the great variability in color pattern shown by *C. prevosti* in other parts of Borneo, *pluto* is very uniform throughout its range, which includes all of North Borneo. Mammae, 3 pairs.

To the south, in the Baram district, *pluto* intergrades with *caroli*. On Labuan the black line below the gray lateral stripe is wider than the stripe itself, and on the basis of this feature a Labuan race, *Callosciurus prevosti rufonigra* Gray, is usually recognized. On Kinabalu above 3,000 feet *pluto* is replaced by a race, *C. p. baluensis* Bonhote (Pendleburg and Chasen, 1932, p. 33), in which the black is strongly ticked with buff, except on the tail, and the feet are rufous. Chasen and Kloss (1931) described the black squirrel on Balambangan Island and Banguay Island as a separate race, *caedis*, on the basis of its slightly smaller skull size (51–53 mm. total length).

Mean and extreme head and body lengths of 11 adults of both sexes from Sapagaya Forest Reserve and the Dewhurst Bay area are 237 (213–267), tail 234 (215–273), hind foot 57.7 (55–61). Skull measurements of the same 11 individuals are: greatest length 54.2 (51.6–57.5), condylobasal length $49.8 \pm .64$ (47–52.6), zygomatic breadth 33.8 (32–35.8), palatal length 26.5 (25–28), upper cheek teeth 10.7 (10.4–11.3). Skulls of eight adults of both sexes from Kalabakan measure: greatest length 55.4 (52.5–57.4), condylobasal length $51.7 \pm .71$ (48.8–54), zygomatic breadth 34.3 (32.8–35.6), palatal length 26.2 (25.1–28.5), upper cheek teeth 10.4 (10.0–11.2). I can detect no significant differences between the sexes in skull measurements.

Mean and extreme weights of 8 adult males were 351 (300–400) grams, of 14 non-gravid adult females 388 (250–500) grams.

The black squirrel is a forest animal. It was seen only in primary and old logged forest, never among the scattered trees in clearings, and rarely in newly-logged forest. We did not find it in town or in cultivated areas.

The species is strictly arboreal and diurnal. It inhabits chiefly the smaller trees of the middle story, although on one occasion an individual was seen feeding in the crown of a huge fig tree (top story), and on another occasion one was on a fallen tree three feet from the ground. According to Banks the nest is a large affair, usually high up in a tree, consisting of "a thick outer layer of fairly big sticks gnawed off by themselves and the inside is lined with much shredded bark and a few grass-like bents, the entrance being usually low down on one side of the bundle."

Stomach contents of five individuals, from primary and old logged forest, consisted mostly of finely-divided pieces of pulpy fruits. Arthropods were present in all stomachs, averaging about 5 per cent of the total food bulk but in one stomach accounting for 35–40 per cent of the total bulk. Arthropods were chiefly ants and termites, but one stomach contained remains of a beetle larva about 40 mm. long, and another an unidentified arthropod about 20 mm. long.

Of 17 adult females collected between April 22 and August 8, three were pregnant (June 20, June 24, August 2); the female killed August 8 was lactating. The pregnant females contained two, two, and three embryos.

Specimens examined.—Total 31. Bukit Kretam (7), Sapagaya Forest Reserve (4), Deramakot (9), Kuamut (1), Kalabakan (8), Bongon (south end of Marudu Bay) (1), Malingai Mt. (1). Chasen and Kloss record it from Samawang, Bettotan, Rayoh, Balam-bangan Island, and Banguay Island, and Allen and Coolidge from Abai. Of *rufonigra* I have seen one (Labuan).

***Callosciurus notatus dilutus* Miller.**

Plantain Squirrel.

Sciurus dultensis dilutus Miller, 1913, Smiths. Misc. Coll., 61, no. 21, p. 23.—Tanjong Batu, Dutch East Borneo, lat. 2° 15' N.

Sciurus notatus dilutus Chasen, 1940, Bull. Raffles Mus. 15: 137.

Color above olivaceous heavily speckled with black; when examined individually the hairs are seen to be colored with alternate annulations of black and buff. Hind feet reddish-buff speckled with black. Belly a dilute ochraceous red, often with a buffy patch in front of the insertion of the thigh. A narrow buff stripe along the side of the body, bordered below by a wider black or dark brown stripe. Tail colored like back, usually but not always with faint annulations.

The colors of the plantain squirrel are very variable, chiefly in the intensity of red in the coloration. In occasional individuals the belly is bright rusty brown, and these individuals also have more red in the colors of the back and tail. Such specimens approach *C. notatus dultensis* of Sarawak and southern Borneo. In other individuals the red is very much diluted and buffy patches begin to appear on the throat and groin.

Many names have been proposed from time to time, as might have been expected in the case of so variable a squirrel. Chasen and Kloss (1931: 26) and Chasen (1940: 137) recognize only two subspecies of *notatus* in Borneo: *dultensis*, with a pale red belly, from Sarawak and Indonesian Borneo, and *dilutus*, with the intensity of the red much diluted, from North Borneo and north-eastern Indonesian Borneo.

Mean and extreme head and body measurements of 17 adults from the Sapagaya Forest Reserve and Dewhurst Bay area are 201 (183–223), tail 186 (160–200), hind foot 48.5 (45–52). Skull measurements of 37 individuals from the Sapagaya Forest Reserve, Dewhurst Bay area, and Sandakan are: greatest length 48.9 (47–50.7), condylo-basal length $45.1 \pm .17$, palatal length $24.4 \pm .11$, zygomatic breadth 28.7 (27.4–30.3), interorbital constriction 17.1 (15.6–18.4). The upper cheek teeth of 41 specimens

measure $9.18 \pm .053$ (8.4–9.8). None of the skull measurements differs significantly from the corresponding measurements in a series of 23 *C. n. dilitensis* from Kuching, Sarawak. The mean weight of 11 adults was 208 grams, with extremes 175–230.

The plantain squirrel is the most common squirrel in areas that have been heavily disturbed by man.

On Kinabalu it is found up to 5,500 feet (Allen and Coolidge). This species does not appear to be common in the interior of the primary forest, but is abundant around the edges, in clearings, and in secondary growth. It is often seen in towns and cities, and does considerable damage to coconut and rubber plantations. One of our specimens was feeding on jakfruit. In the forest it is an inhabitant of the middle story.

Despite its abundance there is little detailed information on the habits of this squirrel. It is diurnal. According to Banks it produces "three or four young at a time in some hole in a hollow tree." Of 15 adult females we collected between April 14 and July 30, only three were pregnant. These were collected July 17 and July 18. Each contained 3 embryos.

Specimens examined.—Total 45. Sandakan (4), Sandakan mi. 8 (21), Sapagaya Forest Reserve (9), Bukit Kretam (9), Deramakot (2). Chasen and Kloss record it from Samawang, Bettotan, and Rayoh; Allen and Coolidge from Abai and Mt. Kinabalu; and Motley and Dillwyn from Labuan.

***Callosciurus albescens adamsi* Kloss.**

Sciurus adamsi Kloss, 1921, Jour. Straits Br. Roy. Asiatic Soc., 83: 151.—Upper Baram River, N.E. Sarawak.

Sciurus albescens adamsi Chasen, 1940, Bull. Raffles Mus., 15: 140.

This squirrel is indistinguishable from *C. notatus dilutus* except in size and in having a buff-colored patch behind the ear. Measurements of an adult female from the Sapagaya Forest Reserve are: head and body 183, tail 152, hind foot 40. Skull measurements of the same individual are: greatest length 43.5, condylobasal length 40, zygomatic breadth 26, interorbital breadth 16.2, upper cheek teeth 8.2.

This rare squirrel (our specimen is only the sixth that has been recorded) lives side by side with *C. notatus dilutus*. Our specimen was collected at 8:00 a.m. in old logged forest. It was pregnant (July 18), and contained 2 embryos.

The similarity in the *Callosciurus notatus*—*Callosciurus albescens* situation and the *Tupaia minor*—*Tupaia gracilis* situation in North Borneo is striking. A pair of olive-colored species is involved in both, and in each case one species of the pair (*C. notatus*, *T. minor*) is very common whereas the other (*C. albescens*, *T. gracilis*) is very rare.

Specimens examined.—Sapagaya Forest Reserve (1). Chasen and Kloss record it from Bettotan and Rayoh.

***Sundasciurus hippurus pryeri* Thomas.**

Horse-tailed Squirrel.

Sciurus Pryeri Thomas, 1892, Ann. Mag. Nat. Hist. (6) 10: 214.—Sapugaia [Sapagaya] River, North Borneo.

Sciurus hippurus pryeri Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 27.—Chasen, 1940, Bull. Raffles Mus., 15: 141.

Sundasciurus hippurus Moore, 1958, Amer. Mus. Nov., 1914: 2.

Upper side of body, including midline of neck and outer side of thighs, bright rufous faintly speckled with black. Head, sides of neck, shoulders, and inner side of arms gray. Underside, including underside of fore and hind legs, cream sometimes lightly washed with rufous. Tail gray with indistinct black rings. Mammary, 3 pairs.

A series of 23 specimens of this squirrel from North Borneo shows considerable variation in the color of the underparts, but is otherwise quite uniform. In four specimens from Sandakan mi. 8 the belly is cream. In six from the Sapagaya Forest Reserve (topotypes) the belly is cream in only one, being very faintly washed with buffy red in the other five. Among eight from Bukit Kretam, the belly is cream in two and washed to varying degrees with buffy red in the other six; in two the reddish wash is as deep as in *inquinatus*, but the dorsal coloration is indistinguishable from that of light-bellied specimens. Among six from Deramakot the underparts are cream in two and washed with buffy red in four; in one of these the belly is pale rufous as in *inquinatus*.

Chasen and Kloss (1931) distinguished four races of *hippurus* in Borneo as follows:

hippurellus Lyon—Red underparts, dark tail, forearm brown, SW Borneo, SW Sarawak

borneensis Gray [= *grayi* Bonhote]—Red underparts, dark tail, forearm gray outside. Sarawak; Dutch East Borneo

inquinatus Thomas—Pale rufous underparts, gray tail, forearm particolored. Lawas River, Brunei

pryeri Thomas—White underparts, gray tail, forearm particolored. North Borneo.

There is obviously a geographic gradient, the amount of red in the total coloration increasing from north to south. Whether *inquinatus* represents a good race must await the accumulation of larger series.

Measurements of 14 adults from the Sapagaya Forest Reserve and Bukit Kretam are: head and body 226 (213–238), tail 220 (176–244) hind foot 58 (55–61). Skull measurements of 25 adults from these two localities and Deramakot are: greatest length 54.6 (53.2–56), condylobasal length $51.0 \pm .197$ (50–52.7), zygomatic breadth 32.3 (30.6–34.2), interorbital constriction 18.1 (17.1–19.5), upper cheek teeth $10.2 \pm .071$ (9.5–10.7). The incisors are much heavier than in *Callosciurus*.

The mean weight of 17 adults was 300 grams, extremes 260–365 grams.

This squirrel appears to be a forest animal. It was seen most often in primary forest, but was also common in old logged forest; it was not observed in clearings or in town. All individuals observed by me (14 in all) were in trees, from ten feet to about 40 feet from the ground. These were the smaller trees of the second story, not the huge trees that form the canopy. *Sundasciurus hippurus* thus appears to live in the lower middle story of the forest. Hose (1893) states that "this squirrel is usually seen on the ground, but takes refuge in the trees when frightened," but at no time did we see an individual on the ground.

Nothing has been recorded of the food and feeding of this species. On one occasion I observed three individuals feeding in a *Canarium commune* tree in primary forest. This is a common wild and cultivated tree. The ground under the tree was littered with small chips of fruit, like coconut in color and consistency. Endocarps on the ground, each about 35 mm. long, each had a neat hole 8–10 mm. in diameter chiselled in the side through which the contents had been removed.

Stomach contents of seven individuals, all taken in primary forest, consisted almost exclusively of the remains of pulpy fruits. One stomach had fragments of an earthworm, another fragments of a small insect, and a third contained about two dozen dipteran larvae, 8 mm. in length, all intact.

Fifteen adult females were collected between 25 April and 5 August. None of these was pregnant, which suggests that the breeding season falls during some other part of the year.

Specimens examined.—Total 29. Sandakan mi. 8 (6), Bukit Kretam (8), Sapagaya Forest Reserve (6), Deramakot (6), Kalabakan (2), Bongon (1). Chasen and Kloss record it from Samawang and Bettotan.

***Sundasciurus lowi lowi* Thomas.**

Low's Squirrel.

Sciurus lowii Thomas, 1892, Ann. Mag. Nat. Hist., (6) 9: 253.—Lumbidan, Sarawak.

Sciurus lowii lowii Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 28.—Chasen, 1940, Bull. Raffles Mus., 15: 143.

Sundasciurus lowi Moore, 1958, Amer. Mus. Nov., 1914: 2.

A small short-tailed squirrel. Color above dark brown heavily ticked with reddish buff. Each individual hair is very dark brown with a single pale band near the tip. Cheeks and a poorly defined ring around the eye reddish buff. The entire underside of head, body, and legs pure cream with a faint reddish wash of varying intensity, sharply separated from the darker dorsal coloration; in one specimen the red is quite pronounced. Tail darker than body, faintly ringed with orange and black. The tail is very frequently damaged during life; 5 of 11 individuals had incomplete tails, and Banks mentions the frequency of "shortened or broken tails." The pelage of this squirrel is soft and silky.

Mean and extreme head and body lengths of 11 adults from the Sapagaya Forest Reserve and Bukit Kretam are: 144 (132–156), tail 84 (85–97), hind foot 35.4 (32–37). Skull measurements of 21 adults from the Sapagaya Forest Reserve, Bukit Kretam, Deramakot, and Kalabakan are: greatest length 39.0 (37.2–40.3), condylobasal length 35.3 (33.5–36.4), zygomatic breadth 22.9 (21.6–23.5), interorbital constriction 11.9 (11.1–13.6), upper cheek teeth 7.5 (7.0–7.8). The mean weight of 11 adults was 93 grams, extremes 60–120 grams.

The form on Banguay Island was described as a distinct race, *T. l. bangueyae*, by Thomas (1910, Ann. Mag. Nat. Hist. (8) 5: 386). Chasen and Kloss, after examining additional material from Banguay, concluded that it is indistinguishable from the mainland form, but Chasen (1940) later reversed this opinion. The entire mainland population is regarded as representing a single subspecies.

This squirrel seems to be uncommon in some parts of Borneo (e.g., Banks 1931), but was quite abundant in the areas where we collected. Motley and Dillwyn state that it was "very abundant" on Labuan. It is strictly a forest animal, living on the ground. It appears to be diurnal; we never saw it at night. Individuals were most often seen climbing around the roots and buttresses of the large trees, or scampering over logs and fallen branches. We never observed them more than ten feet above ground.

A captive showed very squirrel-like behaviour, and was not inclined to be vicious or unduly nervous. Food was held in the fore paws and manipulated in squirrel fashion. In eating a dried prune, feeding movements were a series of very rapid forward thrusts of the head, during which pieces appeared to be gouged out with the lower incisors and cut off with the upper incisors. The head is then momentarily raised while the food is masticated, and the cycle is repeated. The animal drank from a shallow dish by lapping with the tongue. It slept in a vertical position, with the body arched so that the top of the head rested on the ground between the hind feet, the tail lying forward alongside the body.

Stomach contents of six individuals from various localities in eastern North Borneo were examined. The dominant food items were small arthropods and fruits, in about

equal proportions. Two stomachs contained exclusively animal remains, one exclusively plant remains, and three were mixed. Animal food items were predominantly ants, termites, small lepidopteran larvae, and dipteran larvae. Roaches, wasps, spiders, and beetle larvae were much less numerous. The bulk of the contents of one stomach consisted of the remains of a fungus.

Of 16 adult females collected between 23 April and 8 August, three were pregnant (June 16, June 28, August 1), and a female collected 8 August was lactating. One female contained three embryos, another only two.

Specimens examined.—Total 23. Bukit Kretam (8), Sapagaya Forest Reserve (5), Deramakot (5), Kalabakan (4), Paitan (1). Chasen and Kloss record it from Samawang, Bettotan, Kudat, and Banguay Island, and Allen and Coolidge from Mt. Kinabalu 3,500' and the Kalabakan River.

Rhinosciurus laticaudatus laticaudatus Müller.

Long-nosed Squirrel.

Sciurus laticaudatus Müller, in Temminck, 1844, Verh. Nat. Ges. Ned. Overz. Bezitt., Zool., p. 100.—Pontianak, West Borneo.

Rhinosciurus laticaudatus laticaudatus Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 28.

A medium-sized, short-tailed squirrel, the tail slender and round in cross section. The muzzle is long and pointed. This squirrel closely resembles the larger treeshrews. Color above uniform dark brown heavily but faintly speckled with orange. Each individual hair is dark brown with a single orange-colored band near the tip. Throat, belly, and inner sides of legs reddish buff, sharply separated from the darker dorsal coloration. Tail dark brown above and below, faintly ringed with reddish buff.

Measurements of two adults, given by Chasen and Kloss, are: head and body 195, 217; tail 170, 135; hind foot 40, 44. Skull measurements of the same two individuals are: greatest length 58.1, 59; condylobasal length 51.3, 51.2; zygomatic breadth 26.2, 27.5; interorbital constriction 13.1, 13; upper cheek teeth 11.6, 12.2.

All collectors agree that this squirrel is very rarely seen. Robinson and Kloss (in Thomas, 1909, *Jour. Fed. Malay States Mus.*, 4: 120) state that the closely related *R. l. tupaoides* in the Malay Peninsula is "strictly terrestrial and very shy, which accounts for their rarity in collections. Their diet, judging from numerous specimens that we have examined, is principally insectivorous, consisting of large ants and beetles. The tongue is very long and protrusible . . . The animals are generally found in the neighbourhood of large and rotten logs and, at the least alarm, take refuge beneath or in any available hole."

Locality Records.—Chasen and Kloss record two specimens from Bettotan and Benoni. These are the only North Bornean records known to me.

Nannosciurus exilis exilis Müller.

Pigmy Squirrel.

Sciurus exilis Müller, 1838, Tijdschr. Nat. Geschied. Physiol., 5: 148.—Kapas River basin, West Borneo.

Nannosciurus exilis sordidus Chasen and Kloss, 1931, Bull. Raffles Mus. 6: 291 (Samawang, Bettotan, and Gomatong).

Nannosciurus exilis relictus Thomas, 1910, Ann. Mag. Nat. Hist. (8) 5: 387.—Banguay Island.—Chasen, 1940, Bull. Raffles Mus. 15: 150.

Exilisciurus exilis Moore, 1958, Amer. Mus. Nov. 1914: 4.

A very small squirrel with tail shorter than head and body. Color above olive finely ticked with slate, heavily washed with cinnamon-rufous, heaviest along dorsal midline; hairs slate-colored at their bases. An orange ring around eye. Underparts salmon-buff, the slate-colored bases of the hairs showing through. Tail darker than

upper surface of body; hairs orange at base, followed by a black band, and tipped with buff. Hands and feet paler than upper surface of body.

Mean and extreme measurements of six adults from Bukit Kretam and the Sapagaya Forest Reserve are: head and body 73.2 (67–79), tail 49.2 (42–62), hind foot 22.2 (21–23). Skull measurements of four of these are: greatest length 22.7 (22.4–22.9), condylobasal length 19.7 (19.0–20.3), zygomatic breadth 14.2 (14.1–14.2), palatal length (including spine) 10.5 (10.2–10.7), upper cheek teeth 3.7 (3.7–3.8). An adult male from Deramakot and an adult male from Kalabakan each weighed 15 grams.

There is considerable variation in the amount and intensity of cinnamon-rufous in our series, ranging from almost no red in one individual to a heavy wash over the entire upper surface of the body in others. Specimens from North Borneo are very slightly paler than three specimens from the Rejang River area of Sarawak. Our North Bornean animals are not "very distinct" from Sarawak animals, as stated by Chasen and Kloss.

The pigmy squirrel represents a typical case of dwarfing: the brain-case is disproportionately large and globular with no indication of crests or ridges, the orbits and auditory bullae are disproportionately large, and the face and teeth disproportionately small.

We found this squirrel quite common in both primary and old logged forest. It was most often seen in the lower story, but was also observed in the middle story, 40 feet or more above ground. Individuals were usually on the trunks of the smaller trees forming the middle story, less often on vines or the buttresses of large trees.

An individual was observed through binoculars for about 15 minutes. It worked its way up the trunk and along a lateral branch of a small tree, seemingly feeding on something. It moved with equal ease in all positions, including upside down on the underside of the branch, and on the vertical trunk moved head upward or head downward indifferently. The general behavior was squirrel-like. The tail was flicked at frequent intervals. The voice of this squirrel is a high-pitched mouse-like squeak.

Stomach contents of four individuals were examined, all taken in old logged forest in the Sapagaya Forest Reserve. All contained very finely divided plant tissue, which was not further indentifiable. Three of the four stomachs also contained minute ants, ranging from a few individuals in two stomachs to about 40 per cent of the total food bulk in a third.

Of seven females collected between May 22 and August 10, two were pregnant. Both were taken July 20, and each contained two young.

Specimens examined.—Total 12. Sandakan mi. 8 (1); Sapagaya Forest Reserve (4); Bukit Kretam (5); Deramakot (1); Kalabakan (1). Chasen and Kloss record this species from Bettotan, Samawang, Gomantong, and Banguay Island; and Allen and Coolidge from Abai.

***Paralariscus hosei* Thomas.**

Striped Ground Squirrel.

Sciurus hosei Thomas, 1892, Ann. Mag. Nat. Hist. (6) 10: 215.—Mt. Batu Song, Baram District, Sarawak.

Lariscus hosei Chasen, 1940, Bull. Raffles Mus., 15: 147.

Lariscus (Paralariscus) hosei Ellerman, 1947, Proc. Zool. Soc. London 117: 259.

Paralariscus hosei Ellerman, 1949, The families and genera of living rodents, vol. 3, pt. 1, p. 21.

A medium-sized slender-tailed squirrel distinguished by nine prominent stripes on the back. Back with a median reddish buff line beginning at occiput and extending to base of tail. This is bordered by a wide black line beginning behind the shoulder and

extending to base of tail, then a narrow yellowish white line, another wider black line, and finally an indistinct buff colored line. Head, neck, sides of body, and outer sides of legs olivaceous gray, suffused with red on nape and shoulders. Throat, belly, and inner sides of legs cream color heavily washed with red. Tail not bushy, dark above, lighter below, the hairs broadly ringed with orange and black; tips of hairs orange.

The only form with which this might be confused is *Lariscus insignis diversus*, to which it apparently is not closely related. The latter, which has not yet been recorded from North Borneo, lacks the red median stripe and has only three black stripes instead of four as in *hosei*, and there are other differences in the skull and dentition. The cheek teeth are remarkable for their breadth and the almost complete absence of cusps. The last upper molar is only about half the size of the tooth anterior to it.

The single North Bornean specimen of this form available to me appears to be rather paler, especially on the belly, than the type, although I have not been able to compare it. Our specimen is much paler below than one from the Kelabit Plateau, Sarawak.

Measurements of an adult female: head and body 189, tail 122, hind foot 46. Skull measurements of the same individual are: total length 45, condylobasal length 42.3, interorbital constriction 12, "orbital length"¹⁴ 15.2, upper cheek teeth 9.3. The weight of this individual was 215 g.

This squirrel appears to be excessively uncommon, and continuous efforts for a month after the first individual was collected failed to produce a second. Our specimen was shot on the ground, during the middle morning hours, in primary forest. It was collected July 25, and contained two embryos.

Specimens examined.—Sapagaya Forest Reserve (1).

FLYING SQUIRRELS

Subfamily PETAURISTINAE

The tropical forests of the Orient are the headquarters of the flying squirrels of the world. No fewer than seven genera occur in Borneo. Many of the flying squirrels are excessively rare, at least in collections, and the distribution of these seven genera in Borneo is not well known. Only three have been recorded from North Borneo, although others undoubtedly occur there. The genera *Iomys*, *Pteromyscus*, *Petaurillus*, and *Aeromys*, known from other parts of Borneo, have not been recorded from North Borneo.

KEY TO THE FLYING SQUIRRELS OF NORTH BORNEO

- 1 a. Size large, head and body about 400 mm.; tail round in cross section . . . *Petaurista petaurista*
- b. Size smaller, head and body less than 400 mm.; tail flat in cross section 2
- 2 a. Head and body about 350 mm.; general color chestnut *Hylopetes thomasi*
- b. Head and body about 100 mm.; general color very dark silvery gray, white below
Petinomys setosus

¹⁴. Lacrimal to posteriormost point on the anterior border of the posterior zygomatic root; see Ellerman, 1947, p. 259.

Petaurista petaurista rajah Thomas.Giant Flying Squirrel, *Kubong merah*.*Pteromys melanopis* Motley and Dillwyn, 1855, Contrib. Nat. Hist. Labuan, p. 2.*Petaurista nitida rajah* Thomas, 1908, Ann. Mag. Nat. Hist. (8) 1: 251.—Mt. Dulit, Baram District, Sarawak.*Petaurista petaurista rajah* Chasen, 1940, Bull. Raffles Mus., 15: 112.

A very large red flying squirrel with a long cylindrical tail. Color above rich reddish bay, darkened in irregular patches by the darker tips of the hairs. Worn places in the pelage are much paler. Underfur reddish cinnamon. Throat, belly, and inner sides of legs uniform reddish cinnamon. Orbital ring, a small area around the muzzle, ears, and feet black, the black of the feet extending for some distance along the edges of the patagium and the lateral surfaces of the base of the tail. Tail paler than body above, colored like belly below, and with a black tip.

In the Kalabakan specimen the underfur is grayish buff. This produces a darker, chestnut effect on the upper parts, without the vividness of the Bukit Kretam specimen. Underparts in this individual are pale reddish buff. Motley and Dillwyn state that the juvenile color is "dull ashy gray," quite unlike that of adults.

Measurements of an adult male are: head and body 400, tail 415, hind foot 78. Skull measurements of the same individual and an adult female from Kalabakan are: greatest length 68, 69.5; condylobasal length 64.5, 64.2; palatal length 35.4, 35.6; zygomatic breadth 45, 46.7; interorbital constriction 14, 15.6; upper cheek teeth 15.6, 15.6. Weights of these two animals were 1,325 and 1,350 grams.

The Bukit Kretam specimen parachuted out of primary forest at 6:00 p.m. onto a large isolated tree in the centre of a clearing, landing head uppermost about 60 feet high on the trunk. The stomach was filled with well-chewed green material. Several individuals observed at Kalabakan and Sungei Tibas were more than 100 feet above ground when they took off, and glided at least 100 yards. According to Hose (1893) they live "during the daytime in holes about thirty to a hundred feet up the trunk, and coming out in the evening just at sundown. They breed in holes, not making a nest, and have from two to four young ones." Banks (1931) says that a captive was "remarkably fierce, growled and advanced threateningly when annoyed, curiously enough striking out suddenly with one or both of its sharp-clawed forefeet." On the ground it progressed "in a series of rather awkward hops."

The Kalabakan specimen was lactating (June 10).

Specimens examined.—Bukit Kretam (1), Kalabakan (1).

Hylopetes thomasi Hose.*Petaurista thomasi* Hose, 1900, Ann. Mag. Nat. Hist. (7) 5: 215.—Silat River, Sarawak.*Hylopetes thomasi* Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 19.

A large red flying squirrel with a long flattened tail. Color above "nearly of the vivid rufous characteristic of [*Petaurista petaurista rajah*], but rather deeper and richer." Under surface paler than dorsum. The black markings found in *P. p. rajah* are lacking.

Measurements of the type were given by Hose as: head and body 350, tail 340, hind foot 60. Skull, greatest length 61, basilar length 51, zygomatic breadth 41, interorbital breadth 13.5, upper cheek teeth (excluding p 3) 14.2.

The habits of this rare squirrel are completely unknown. We did not encounter it in our field work.

Locality Records.—Chasen and Kloss record a single specimen from Bettotan.

***Petinomys setosus* Temminck.**

Pteromys (Sciuropterus) setosus Temminck, 1842-45, Fauna Japon., Mamm., p. 49.—Padong, western Sumatra.

Petinomys setosus Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 19.

A small flying squirrel with a strongly distichous tail. Color above "black, the hairs narrowly tipped with silvery grey on the forehead, shoulders, sides of the back and thighs and with dull brownish-buff on the crown, nape, centre of the back and rump. Thighs black, forelimbs almost so: feet thinly clad with brownish hairs. Edge of the membrane, above and below black. Cheeks and underparts white. Tail brownish black, the underside with distinct baso-lateral whitish areas". (Chasen and Kloss, 1931).

Measurements of this individual are given by Chasen and Kloss as: head and body 106, tail 96, hind foot 22.5, ear 14. Skull measurements: total length 29, condylobasal length 25.2, zygomatic breadth 17, interorbital constriction 6.1, upper cheek teeth 5.4.

I have seen only one specimen of this form, an individual from the Kelabit Plateau in northern Sarawak. It agrees very closely with the description given by Chasen and Kloss. Nothing is known of the habits of this squirrel, which appears to be quite rare.

Locality records.—Chasen and Kloss record one specimen from Bettotan.

RATS**Family MURIDAE**

The headquarters of the true rats (genus *Rattus*) is the Oriental tropics, where these rodents form a dominant element of the fauna. Because of their intimate association with man, rats are of considerable economic interest, as competitors for food and as disease vectors.

Aside from the peculiar *Chiropodomys* and *Haeromys*, both highly specialized arboreal mice, *Rattus* is the only genus of the Muridae that occurs in Borneo. The number of species and subspecies of *Rattus* is considerable, however; Chasen (1940) lists 20 forms from the mainland of Borneo, and this number will certainly be increased. The species vary greatly in size, proportions, color, and degree of spininess of the pelage. Arboreal species tend to have long tails, broad hind feet, and long ears; terrestrial species shorter tails, narrow hind feet, and short ears.

In the New World tropics the ecological counterparts of the several species of *Rattus* are distributed among many genera representing two suborders: the Myomorpha and Hystricomorpha. Adaptive radiation within the genus *Rattus* is not as extensive as among the much more numerous species of Neotropical rodents, but in several instances parallelism is astonishingly close. There are no truly aquatic or burrowing rodents in Borneo. *Rattus mulleri* closely resembles *Nectomys*, an aquatic cricetine, except that the hind feet are not as large. *Rattus rajah* and *Rattus surifer* are very similar to *Proechimys*, a common terrestrial hystricomorph. *Rattus whiteheadi* is the counterpart of the more generalized forms of *Oryzomys*. *Rattus sabanus* and *Rattus rapit* occupy the same ecological niche as *Thomasomys aureus*, a large semi-arboreal cricetine. *Rattus cremoriventer* closely resembles the arboreal forms of *Oryzomys* (subgenus *Oecomys*).

Ellerman (1940) divided the genus *Rattus* into seven subgenera on the basis of skull characters. Whether or not these represent natural groups, the characters are useful in distinguishing species in this difficult genus and Ellerman's arrangement has been followed here.

- 10 a. Under fur of belly gray *R. surifer bandahara*
 b. Under fur of belly white *R. rajah rajah*
- 11 a. Tail about 1/5 or less longer than head and body 12
 b. Tail about 1/2 longer than head and body. Body color rufous, streaked with brown; belly pure cream *R. sabanus sabanus*
- 12 a. Hair coarse, without spines. Color coarsely grizzled buff and black; belly dirty buff *R. mulleri borneanus*
 b. Pelage thickly spinous, color fawn streaked with brown; belly white or cream *R. rajah rajah*

1. *Rattus* Group

Medium-sized rats with short harsh fur. In this group the tail is usually longer than head and body, but in the Bornean forms it appears to be about the same length or even a little shorter. Mammae, in Bornean forms, $2-3 = 10$ or $2-2 = 8$. In the skull (fig. in Key) the bullae are larger and well inflated, the palate is long (more than $\frac{1}{2}$ total skull length), and the palatal foramina are long and slit-like.

Rattus rattus turbidus Miller.

Epimys rattus turbidus Miller, 1913, Smiths. Misc. Coll., 61, no. 21, p. 12.—Tanggarong, south bank of Mahakam River, southeastern Borneo.

Rattus rattus turbidus Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 35.

A medium-sized rat with tail about as long as head and body. The hair is short and almost or quite spineless. Color above dark brown becoming slightly lighter on sides; hairs slaty at base. Underparts gray, with slate-colored underfur, not sharply set off from color of sides. Hands and feet whitish, but metapodials often dark brown along center. Tail unicolor dark brown, fairly well haired but not tufted. Mammae 2—3 = 10.

Measurements of a single adult female (followed in parentheses by measurements of an adult male from Bettotan, as given by Chasen and Kloss) are: head and body 149 (144), tail 148 (141), hind foot 32 (29). Skull measurements of the same two individuals are: greatest length—, (36.5), condylobasal length 32.8 (32.5), zygomatic breadth 18 (18), upper cheek teeth 6 (6). Weight 60 grams.

Chasen and Kloss noted that their one specimen from near Sandakan was "rather darker" above than typical *turbidus*. This is likewise true of our one specimen, which lacks the buff elements present in a specimen from Samarinda, which is within a few miles of the type locality of *turbidus*. The description of *banguiei* (Chasen and Kloss, 1931, *Bull. Raffles Mus.*, 6: 35, Banguay Island) fits North Bornean specimens closely, and perhaps this name should be applied to the North Bornean form. I have not seen specimens from Banguay.

In Sarawak and southwestern Borneo *turbidus* is replaced by another race, *jalo-*
rensis [= *neglectus* of authors], in which the underparts are white instead of gray.

Our specimen was taken in a dwelling in a clearing at the edge of high forest.

Specimens examined.—Bukit Kretam (1). Chasen and Kloss record it from Bettotan.

Rattus rattus diardi Jentink.

Malaysian House Rat.

Mus diardi Jentink, 1880, Notes Leyden Mus., 2: 12.—West Java.

Rattus rattus diardi Chasen and Kloss, 1928, Jour. Malayan Br. Roy. Asiatic Soc., 6: 46.

A medium-sized rat, slightly larger than *R. r. turbidus*, with tail about as long as head and body. The hair is short, coarse, and slightly spiny. Color above brown streaked with brownish black; hairs slaty at base. Underparts dull drabby gray with a rufous wash.

with slate-colored underfur, not sharply set off from color of sides. An adult male from Labuan has a white blaze on the underside of the neck. Hands and feet white, with or without a brownish line down the center. Tail unicolor dark brown. Mammae 2-3 = 10.

Mean and extreme measurements of four individuals from Sandakan and Labuan are: head and body 176.5 (151-219), tail 158.5 (121-185), hind foot 36.2 (35-38). Skull measurements of the same specimens are: greatest length 41 (largest individual only), condylobasal length 38.4 (36.5-40) zygomatic breadth 19.5 (18.4-20.5), palatal foramina 7.4 (7-7.8), upper cheek teeth 6.8 (6.5-7).

Chasen and Kloss have mentioned in various writings the variability of this rat in color, size, and skull measurements. My series is not large enough to verify this.

We did not encounter this rat in the forest, all our specimens being taken in town. It is said to be found occasionally in cultivated land near buildings and villages.

Specimens examined.—Sandakan (2), Labuan (2). Chasen and Kloss record it from Kudat.

***Rattus exulans ehippium* Jentink.**

Mus ehippium Jentink, 1880, Notes Leyden Mus. 2: 15.—Sumatra.

Rattus concolor ehippium Chasen, 1940, Bull. Raffles Mus., 15: 160.

Rattus exulans ehippium Ellerman, 1949, The families and genera of living rodents, vol. 3, part 1, p. 47.

A small rat with tail a little longer than head and body. The pelage is coarse and rather spiny. Color above dull gray, varying to rufous especially in old individuals. Spines white, tipped with dark brown. Underparts dirty grayish white, the bases of the hairs gray. Hands and feet white, the feet with or without a brown line down the center. Tail unicolor brown. Mammae 2-2 = 8.

Mean and extreme measurements of 5 specimens from near Sandakan (collected by F. C. Wonder) are: head and body length 109.5 (101-117), tail 124.5 (123-126), hind foot 25.8 (25-28). Skull measurements of the same specimens are: greatest length 29.9 (29.5-30.5), condylobasal length 27.5 (26.5-28.6), zygomatic breadth 14.2 (14-14.6), palatal foramina 5.0 (4.6-5.4), upper cheek teeth 5.2 (5-5.5).

This species is easily recognized by its small size and gray belly. We did not encounter it in our field work. According to Chasen (1940: 159) it is usually found in or near human settlements.

All Bornean *exulans* are referred to this subspecies.

Specimens examined.—Sandakan mi. 8 (5), Labuan (1). Chasen and Kloss record it from Bettotan, Kudat, and Banguay Island.

2. *Stenomys* Group

Rattus mulleri and *R. infraluteus* are the only Bornean representatives of this group. Both are large rats with short coarse fur, small ears, broad hind feet, and tail not elongated. Mammae 2-2 = 8. In the skull the bullae are small, the palate long (more than half total skull length), and the palatal foramina long and slit-like. These appear to be essentially ground-dwelling rats.

Rattus mulleri borneanus Miller.

Epimys borneanus Miller, 1913, Smiths. Misc. Coll., 61, no. 21, p. 15.—Telok Karang Tiga, Southeast Borneo.

Rattus muelleri borneanus Chasen and Kloss, 1928, Jour. Malayan Br. Roy. Asiatic Soc., 6: 47.

A large rat with tail about a fifth longer than head and body. The pelage is coarse, without spines or shorter bristles. Color above coarsely grizzled buff and black. Belly dirty buff, sometimes washed with gray at mid-body; entire underparts washed with rufous in one specimen. Color of belly not sharply set off from color of sides. Hands and feet nearly naked, metapodials with a brown line down the center. Tail unicolor brown, short-haired.

Mean and extreme head and body lengths of eight adults from Bukit Kretam and the Sapagaya Forest Reserve are 208.3 ± 6.48 (186–239, tail 250.5 ± 9.11 (223–277), hind foot 44.6 ± 1.4 (39–49). Skull measurements of these eight plus two from Kalabakan are: greatest length 50.7 (46–53.5), condylobasal length $47.5 \pm .73$ (43.4–50), palatal length 27.1 (25.4–29.2), palatal foramina 8.6 (7.8–9.1), zygomatic breadth 24.5 (23–26), upper cheek teeth $9.08 \pm .11$ (8.5–9.5). Mean and extreme weights of 8 adults was 243 (160–305) grams. Skull dimensions of these North Bornean specimens are significantly less than in a series of 22 specimens from Kuching, Sarawak: condylobasal length $49.6 \pm .4$, upper cheek teeth $9.3 \pm .10$.

This is the common large rat of North Borneo. It tends to be parasitic on man, and is common in clearings, both inside and outside dwellings. It also occurs in the forest, and individuals are often seen scurrying about the forest floor at night. In the forest we trapped it both on the ground and at low levels (6 feet) in trees; there was no evidence that it is aquatic. This species is usually heavily infested with fleas. In captivity individuals are inclined to be savage.

According to Chasen (1940), *mulleri* is replaced by *infraluteus* Thomas "at high levels on Mt. Kinabalu."

A pregnant female contained three young (July 26).

Specimens examined.—Total 10. Bukit Kretam (6), Sapagaya Forest Reserve (2), Kalabakan (2). Chasen and Kloss record it from Bettotan, Gomantong, Banguay Island, and Balambangan Island.

3. *Maxomys* Group

Small to medium-sized rats with numerous short soft spines in the pelage. Tail about a third longer than head and body. In the skull the palate is short (less than half total skull length), the bullae small, and the palatal foramina long. Arboreal.

Rattus cremoriventer kina Bonhote.

Pencil-tailed Rat.

Mus kina Bonhote, 1903, Ann. Mag. Nat. Hist., (7) 11: 124.—Mt. Kinabalu, North Borneo.

Rattus cremoriventer kina Chasen and Kloss, 1928, Jour. Malayan Br. Roy. Asiatic Soc., 6 (1): 46.

A small rat with tail about a third longer than head and body. The pelage contains numerous short soft spines. Color above pale ochraceous, interspersed with very long black hairs, most conspicuous on central dorsal region. Underparts dull white, sharply set off from color of sides; bases of hairs not gray. Fore feet white slightly suffused with ochraceous. Hind feet white, metapodials dark brown. Tail nearly unicolor, only slightly paler on underside, thinly but distinctly tufted at tip.

Measurements of an adult male from Kalabakan: head and body 124, tail 166; skull, greatest length 32.8, condylobasal length 29.6, palatal length 16.3, upper cheek teeth 6.3. Mean and extreme measurements of four adults, as given by Chasen and Kloss (1931) are: head and body 138 (122–155), tail 188 (168–202), hind foot 25.8 (24–27). Skull measurements of the same four specimens are: total length 35.2 (34–36), condylobasal length 29.4 (28–31.5), zygomatic breadth 16.6 (16–17.1), upper cheek teeth 6.1 (5.8–6.2).

On Mallewallé, Banguay, and Balambangan Islands this rat is said to be duller in color and with the underside of the tail pale. Chasen and Kloss (1931: 32) named it as a separate race, *malawali*.

I have seen only one North Bornean specimen of this rat. Nothing has been recorded of its habits. The hind foot is short and broad, apparently in adaptation to arboreal life. The tufted tail also indicates arboreal habits.

Specimens examined.—Kalabakan (1). Chasen and Kloss record this form from Bettotan and Rayoh.

***Rattus rapit rapit* Bonhote.**

Mus rapit Bonhote, 1903, Ann. Mag. Nat. Hist. (7) 11: 123.—Mt. Kinabalu, North Borneo.

Rattus rapit rapit Chasen, 1940, Bull. Raffles Mus. 15: 176.

Rattus fulvescens rapit Ellerman and Morrison-Scott, 1955, Supplement to Chasen (1940), p. 36.

A medium-sized rat with tail about a third longer than head and body. The pelage contains numerous soft spines. Color above "tawny ochraceous, intermixed with black, which predominates along the centre of the back" (Bonhote); underfur gray. Underparts pale cream, sharply set off from color of sides; bases of hairs not gray. Feet dark brown, toes and a line on either side from the ankle white. Tail slightly lighter on underside, ending in a pencil of hairs.

Measurements of the single available specimen, with measurements of the type in parentheses, are: head and body 146 (173), tail 207 (223), hind foot 36 (29.5). Skull measurements are: greatest length 32, condylobasal length 29, upper cheek teeth 5.8 (6 in the type).

Griswold (Allen and Coolidge, 1940) collected this rat at altitudes between 3,080 and 11,000 feet on Mount Kinabalu. It has not been reported from elsewhere in North Borneo, but is known from the Kelabit Plateau in Sarawak (Davis, 1958). The body form indicates that it is arboreal.

Specimens examined.—Mt. Kinabalu, Lumu Lumu (5,500 feet) (1).

4. *Lenothrix* Group

Medium-sized to small rats with thickly spinous pelage. Tail at most only slightly longer than head and body. In the skull the palate is short (less than half total skull length), palatal foramina short, and bullae small.

***Rattus rajah rajah* Thomas.**

Mus rajah Thomas, 1894, Ann. Mag. Nat. Hist., (6) 14: 451.—Mt. Batu Song, Northern Sarawak.

Rattus rajah rajah Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 31.

A medium-sized, long-eared rat with tail slightly longer than head and body. The pelage contains numerous stiff spines. Color above fawn washed with brown, slightly

darker in lumbar region; underfur brown. Underparts white, sharply set off from color of sides. Hands and feet white. Tail thinly haired, bicolor, brown above and white below. In the skull the nasals are prolonged backward beyond the fronto-maxillary suture.

Measurements of two adults, an old male from the Sapagaya Forest Reserve and a young female from Kalabakan, are: head and body 201, 139, tail 178, 162; hind foot 37, 38. Skull measurements: greatest length 46.6, 38.8; condylobasal length 41.7, 35.1; palatal length 19, 20; zygomatic breadth 22.5, —; palatal foramina 7, 6.1; upper cheek teeth 6.8, 6.8. The Kalabakan specimen weighed 95 grams.

The adult male collected by us was caught in a native snare, set on the ground, in primary forest. The female was trapped on the ground in secondary growth. Body proportions in this species suggest terrestrial habits.

Specimens examined.—Sapagaya Forest Reserve (1), Bukit Kretam (1, sub-adult), Kalabakan (1). Chasen and Kloss record it from Bettotan and Samawang.

***Rattus surifer bandahara* Robinson.**

Rattus bandahara Robinson, 1921, Ann. Mag. Nat. Hist., (9) 7: 235.—Mt. Kinabalu, North Borneo.

A medium-sized long-eared rat with tail slightly longer than head and body. Slightly larger than *Rattus r. rajah*. The pelage contains numerous stiff spines, but these are less numerous and more flexible than in *rajah*. Color above bright reddish brown, slightly darker along midline; underfur slaty. Underparts cream color, sharply separated from color of sides. The dorsal color is carried across the underside of the neck as a narrow band, and across the inner side of the hind leg above the ankle, which thus lacks the white seen in *rajah*. Hands and feet white. Tail thickly haired, bicolor, brown above and white below. In the skull the nasals are not prolonged backward beyond the fronto-maxillary suture.

Mean and extreme measurements of 8 individuals, as given by Chasen and Kloss, are: head and body 181 (160–202), tail 201 (187–215), hind foot 40 (38–43). Skull measurements of the same 8 individuals are: condylobasal length 37.7 (35–41), upper cheek teeth 6.9 (6.6–7).

Locality records.—We did not collect this rat. Chasen and Kloss record it from Kudat and Rayoh.

***Rattus whiteheadi whiteheadi* Thomas.**

Mus whiteheadi Thomas, 1894, Ann. Mag. Nat. Hist. (6) 14: 452.—Mt. Kinabalu, North Borneo.

Rattus whiteheadi whiteheadi Gyldenstolpe, 1920, Kungl. Svenska Vet. Akad. Handl., 60, no. 6, p. 42.

A small rat with tail slightly shorter than head and body. Pelage spiny. Color above buffy brown inclining to reddish, slightly darker along midline; underfur gray. Tips of spines, which show through the fur, brown or black; base of spines slaty. Throat and belly buffy ochraceous to rufous, not sharply separated from color of sides; underfur slate color. Hands and feet white. Tail nearly naked, bicolor, brown above and white below. Mammae 2–2 = 8.

Measurements of three adults are: head and body 113, 116, 117; tail 97, 93, 126; hind foot 27, 28, 30. Skull measurements of the same three individuals are: greatest length 31, 31.5, 33.4; condylobasal length 27.9, 28.3, 29.3; zygomatic breadth 14, 14.8, 15.5; upper cheek teeth 5, 5, 5. The largest of these, a male weighed 55 grams.

The three Kretam specimens were trapped on the ground in old logged forest.

Specimens examined.—Total 5. Bukit Kretam (3, one a skull only), Deramakot (1), Lumu Lumu 5,500 feet (1). Chasen and Kloss record it from Bettotan and Rayoh, and Banguay, Mallewallé and Balambangan Islands, and Allen and Coolidge from Mt. Kinabalu, 3,000 to 7,000 feet.

***Rattus baeodon* Thomas.**

Mus baeodon Thomas, 1894, Ann. Mag. Nat. Hist., (6) 14: 452.—Mt. Kinabalu, North Borneo.

Rattus baeodon Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 33.

A small rat with tail about as long as or only a trifle shorter than head and body. Pelage spiny, more so than in *whiteheadi*. Color above "clay color, tinged with tawny-ochraceous, brightest on the cheeks, shoulders, and flanks . . . posterior upper parts washed with vandyke brown" (Chasen and Kloss, 1931); hairs and spines white at base. Belly "buffy-white, sometimes entirely washed with tawny-ochraceous" (Chasen and Kloss); hairs white or pale gray at base; belly color not sharply set off from color of sides. Hands and feet white. Tail bicolor. Mammae 2-2 = 8. In the skull the toothrow is shorter and the teeth smaller and more delicate than in *whiteheadi*.

Mean and extreme measurements of 6 individuals, as given by Chasen and Kloss, are: head and body 134 (126-140), tail 124 (119-133) hind foot 26.8 (25-28). Skull measurements of the same 6 specimens are: total length 34.1 (33.2-35.2), condylobasilar length 28.4 (27.9-29), upper cheek teeth 4.8 (4.1-5).

We did not collect this rat.

Locality records.—Chasen and Kloss record this form from Bettotan and Rayoh.

***Rattus alticola ochraceiventer* Thomas.**

Mus ochraceiventer Thomas, 1894, Ann. Mag. Nat. Hist. (6) 14: 451.—Mt. Kinabalu, North Borneo, below 3,000 feet.

Rattus alticola ochraceiventer Chasen, 1940, Bull. Raffles Mus., 15: 179.

A medium-sized rat with tail slightly longer than head and body. Pelage very spiny both above and below. Color "coarsely grizzled brown and fulvous rufous; belly brilliant fulvous yellow" (Thomas); bases of hairs slaty; color of belly not sharply demarked from color of sides. Hands and feet white or pale brown. Tail nearly naked, bicolor. Mammae 2-2 = 8.

Head and body about 145, tail about 150, hind foot about 31.5.

Locality records.—Recorded only from Mt. Kinabalu.

5. *Leopoldamys* Group

Large rats with very long tails. Pelage thinly spinous. In the skull (fig. in Key) the palate is of medium length, the palatal foramina short, and the bullae very small.

***Rattus sabanus sabanus* Thomas.**

Mus sabanus Thomas, 1887, Ann. Mag. Nat. Hist. (5) 20: 269.—Mt. Kinabalu, North Borneo.

Rattus sabanus sabanus Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 29.

A large rat with tail half again as long as head and body. The pelage is thinly spinous. Color above rufous, coarsely streaked with dark brown on back, becoming bright rufous on sides; underfur gray. Belly pure cream, sharply set off from color of sides, without slaty bases to hairs. Hands and feet white with a dark line down the centre. Tail not bicolor, only very slightly lighter below. Mammae 2-2 = 8.

Measurements of an adult male from Bukit Kretam are: head and body 240, tail 370, hind foot 50. Skulls, of two adult males: greatest length 55, 57; condylobasal length 48.5, 53.3; zygomatic breadth 27, 25.7; palatal length 28.7, 29.4; palatal foramina 8.5, 7.8; upper cheek teeth 9.5, 9.8. Weight 325 and 375 grams.

This appears to be a "jungle rat." It was not seen in clearings or human habitations, but was occasionally observed at night in the forest. It seems to be arboreal, as the long tail would indicate; individuals were usually seen climbing on lianas or small trees in the lower story. The specimen taken by us was trapped on the ground, however, in old logged forest.

Specimens examined.—Bukit Kretam (1), Kalabakan (1). Chasen and Kloss record it from Bettotan and Rayoh, and Allen and Coolidge from Mt. Kinabalu at 3,300 and 7,000 feet.

***Chiropodomys pusillus* Thomas.**

Pencil-tailed Mouse.

Chiropodomys pusillus Thomas, 1893, Ann. Mag. Nat. Hist. (6) 11: 345.—Mt. Kinabalu, North Borneo, 1,000 feet.

A small fawn-colored mouse with a tufted tail somewhat longer than the head and body. On the hind foot the hallux is short, opposable, and without a claw. The pelage is short and velvety. "General colour tawny fawn, head and centre of back darker, sides paler, outer sides of arms and legs like back, but the wrists and ankles greyish, a color which also extends upon the metatarsus; fingers and toes white; under surface from chin to anus pure white; no darker markings on face; ears small, evenly oval, practically naked. Tail but little longer than the head and body combined, uniformly brown above and below" (Thomas).

Measurements of the type, as given by Thomas, are: head and body 76, tail 81, hind foot 15.8; skull measurements: upper length 22.2, interorbital breadth 4.2, diastema 6.2, anterior palatal foramina 2.7, combined lengths of first two molars (third molar lost) 2.5, lower molar series 3.1.

I have not seen specimens of this genus from North Borneo. It is evidently arboreal. Besides *pusillus*, two additional species, *C. legatus* Thomas and *C. pictor* Thomas, have been described from Mt. Kinabalu, but neither of these is known from below 3,000 feet.

***Haeromys margarettae* Thomas.**

Pigmy Mouse.

Mus margarettae Thomas, 1893, Ann. Mag. Nat. Hist. (6) 11: 346.—Penrissen Hills, Western Sarawak.

Haeromys margarettae Thomas, 1911, Ann. Mag. Nat. Hist. (8) 7: 208.

A small reddish-brown mouse with tail about twice as long as head and body. Thumb prominent and opposable, with a large nail; hallux opposable, its claw reduced to a minute conical point. General color reddish brown above, underfur gray. Underparts white, but "throat washed with the colour of the upperparts" (Chasen and Kloss, 1931). Hands and feet white, with darker median patches on the metapodials. Tail finely haired, almost naked, black above and below.

The skull is similar to that of *Chiropodomys*—short and broad, with a rounded brain case and short, narrow palatal foramina. The molars are rounded as in *Chiropodomys*, but the cusp pattern is as in *Mus*.

Measurements of the type, as given by Thomas, are: head and body 76, tail 144, hind foot 19.7. Skull, total length 25.5, basal length 21.5, zygomatic breadth 13, brain case breadth 12.2, anterior palatal foramina 3.6, upper cheek teeth 3.7.

I have not seen this rare mouse, which apparently is known from only two specimens. The type came from Sarawak, and Chasen and Kloss recorded a second specimen from Bettotan in North Borneo. This is one of the few genera of mammals that appear to be confined to Borneo. A second species, *H. pusillus* (Thomas, 1893, *Ann. Mag. Nat. Hist.* (6) 12: 232), from Mt. Kinabalu, was described as similar to *H. margarettae* except that it is much smaller.

PORCUPINES

Family HYSTRICIDAE

Three genera of porcupines are known from Borneo. Each is the most primitive representative of its respective group. The primitive long-tailed porcupines are represented by *Trichys*, and the more specialized short-tailed porcupines by *Thecurus*, in which the nasal bones are short and narrow, and *Hystrix* in which they are long and broad. The Bornean representative of *Hystrix* (*H. brachyura longicauda* Marsden) apparently has not been reported from North Borneo.

Trichys lipura lipura Günther.

Long-tailed Porcupine.

Trichys lipura Günther, 1876, *Proc. Zool. Soc. London* 1876: 739.—mainland of Borneo, opposite island of Labuan.

Trichys lipura lipura Chasen and Kloss, 1931, *Bull. Raffles Mus.*, 6: 39.

A small long-tailed porcupine, remarkably ratlike in appearance. The body is covered above and below with coarse spines, flat and grooved on both surfaces, among which are mixed a few long hairs. There are no quills. Vibrissae numerous, long, and stiff. The thumb bears a flat nail instead of a claw.

Color above dark brown, the color of the terminal half of the spines; the basal half of the spines is white. Belly, throat, and inner sides of arms and legs white. Hands and feet dark brown. Tail covered with imbricated scales, each bearing a single fine hair; a terminal brush of flat, hollow bristles, each white at the base and becoming brown toward the tip.

Mean and extreme measurements of three adults from the Sandakan area are: head and body 375, 395, 437, tail 210, 235, —, hind foot 61, 65, 67. Five adult skulls measure: greatest length 84.6 (81.5–88), condylobasal length 79.1 (76.5–81.7), zygomatic breadth 42.8 (42–44), nasal length 26.9 (24–30), upper cheek teeth 15.9 (15–16.7). Mean and extreme weights of these three adults are 1,625 (1,525–1,750) grams.

One of our specimens was taken at night in a native snare, set on the ground, in primary forest. Two others were taken in a cultivated area. Banks (1931) says he "saw one running about in the jungle in daylight, rippling along with a peculiar snake-like effect." He also states that the tail is "often shaken" but makes no noise, and that the tip is carried curved upward when the animal walks. Hose (1893) agrees that the tail brush does not produce the rattling noise heard in other porcupines.

The tail is often lost during life in this species, which was originally described from a tailless specimen. Of three individuals collected by us, one had the tail completely wanting.

Specimens examined.—Sapagaya Forest Reserve (1), 12 mi. north of Sandakan (2), 8 mi. north of Sandakan (1), Sandakan area (1 skull only). Chasen and Kloss record this species from Bettotan.

Thecurus crassispinis crassispinis Günther.

Thick-spined Porcupine.

Hystrix crassispinis Günther, 1876, Proc. Zool. Soc. London, 1876: 736.—Borneo opposite Labuan Island.*Hystrix crassispinis crassispinis* Chasen and Kloss, 1931, Bull. Raffles Mus. 6: 38; Chasen, 1940, Bull. Raffles Mus. 15: 188.

A medium-sized short-tailed porcupine. The body is covered above and below with coarse flat spines, deeply grooved on the external side, which are replaced on the posterior third of the back by heavy grooved quills up to 5 mm. in diameter.

Color above dark reddish brown flecked with white, the flecking produced by the white tips of some of the spines. Approximately the basal third of each spine is white, which gradually becomes brown toward the center of the spine. A few of the spines on the back, and a much higher percentage on the cheeks, shoulders, and sides of the body, are white-tipped. The heavy quills are white at the base, followed by a brown band of variable width, with a white tip. Belly brown, heavily flecked with white resulting from the white tips of most of the spines. Hands and feet dark brown. Tail clothed with short slender quills at the base, the tip with spines terminating in a short expanded capsule most of which are open at the end; when not open the capsules terminate in an abrupt sharp point.

Measurements of an adult male from Labuk Bay, with measurements in parentheses given by Chasen and Kloss for an adult male from Bettotan, are: head and body 575 (665), tail 90 (135), hind foot 80 (90); skull, greatest length 107.5 (124), condylobasal length 105 (110), zygomatic breadth 56 (63.7), nasal length 36 (37.2), upper cheek teeth 23 (23).

According to Banks (1931) this porcupine is a poor climber, living in burrows under fallen trees and between rocks. Abbott (in Lyon 1911: 114) stated that in south-east Borneo "porcupines seemed the usual inhabitants of caves." This animal is nocturnal in captivity. Food is held between the soles of the fore feet if small; if large it is held between the fore feet and the ground. Banks described them as noisy, "particularly at night, the alarm being a series of chuckles with an occasional grunt." They also stamp the ground with their hind feet when alarmed. The rattle on the end of the tail, formed by the terminal capsules, is used as a warning. When pursued, this animal suddenly stops and runs backward or sideways into its pursuer.

Specimens examined.—Dandulit (Labuk Bay) (1), Sandakan mi. 8 (1 skull only). Chasen and Kloss record three specimens from Bettotan.

CARNIVORA

Four of the seven families of land carnivores are represented in the Bornean fauna; the Canidae, Procyonidae, and Hyaenidae are wanting. The Malay wild dog (*Cuon javanicus*), which is found on the Malay Peninsula and in Java and Sumatra, has been said to occur in Borneo (e.g. Hose 1893). No specimens of a Bornean dog have ever been collected, and Banks and Chasen both believe that sight records are based on village dogs run wild.

Several genera of civets and two species of cats that occur elsewhere in Borneo have not been reported from North Borneo. It is impossible to determine which of these are due to actual absence of these forms in North Borneo and which to inadequate collecting. Some of the forms not now known from North Borneo will certainly be found to exist there.

BEARS

Family URSIDAE

The Malayan bear occurs from Assam through Burma, Indo-china, and on Sumatra and Borneo; it is absent on Java. A Bornean race is distinguished on the basis of slightly smaller size.

***Helarctos malayanus euryspilus* Horsfield.**

Malayan Bear, *Bruang*.

Helarctos euryspilus Horsfield, 1825, Zool. Jour., 2: 221.—Borneo.

Helarctos malayanus euryspilus Chasen, 1940, Bull. Raffles Mus., 15: 89.

A small short-faced bear, pelage short and sleek, with small rounded ears, protrusible lips and tongue, heavily bowed fore legs and long curved claws. The coloration is jet black; muzzle gray back to and sometimes including the eyes; a white or yellowish-white V-shaped or crescent-shaped patch on the chest.

Measurements of an adult (unsexed) skull from "British North Borneo" are given by Pocock (1932) as: total length 236, condylobasal length 218, zygomatic breadth 185, interorbital breadth 58, upper cheek teeth (P⁴-M²) 49. Lyon (1911) gives the following weights for three individuals from southwest Borneo: adult ♂ 123 lbs. (56 kg.), old adult ♂ 138 lbs. (63 kg.), adult ♀ 105 lbs. (48 kg.).

There are few records of the Malayan bear from North Borneo, although it is well known there. The only published records I can find are Pocock's reference to two skulls from "British North Borneo" in the British Museum. An individual was shot at Bukit Kretam after we left; Mr. John Hedley sent me one claw, the only part of the specimen that could be found after I had written him for verification.

The Malayan bear occurs up to 3,000 feet (Hose 1893). It is an excellent climber, "swarming up a thick tree trunk in a series of jerks, the widespread, bow-legged forelegs encircling much of the trunk and pressing the chest against it, the hind legs supplying the motive force" (Banks, 1931). The same author says that food is sometimes held in one forefoot, "the sole bending around to almost touch the undersurface of the arm."

According to Banks "almost anything serves as food." Hose (1893) states that "it is very fond of feeding upon the honey of a very small bee called by the Dyak 'kalulut,' and I have seen holes in trees of very hard wood made by the bear with its claws in its endeavours to get at a nest of these bees." Abbott (in Lyon, 1911) says they attack coconut trees, which they "climb up and eat the 'heart' out of the palm. In a small grove of about ninety trees, near Tanjong Pamukang, the bears had destroyed about half the trees."

Locality records.—Bukit Kretam (claw only).

MARTENS, OTTERS AND THEIR RELATIVES

Family MUSTELIDAE

The mustelid fauna of Borneo is small, consisting of only six species, each representing a distinct genus. All of these have been reported from North Borneo. One (*Helictis orientalis everetti* Thomas) is known only from Mt. Kinabalu, and is not considered here. A seventh genus (*Arctonyx*) is known from peninsular Siam and Sumatra, but does not occur on Borneo.

Martes flavigula saba Chasen and Kloss. Yellow-throated Marten. (Plate 18).

Martes flavigula saba Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 13.—Bettotan, near Sandakan, North Borneo; Chasen, 1940, Bull. Raffles Mus., 15: 90.

A large marten with a long cylindrical tail. Coloration: top of head, neck, and anterior half of body light brown, with a golden wash on nape and shoulders in one specimen. Posterior half of body darker brown, darkest along midline. A dark brown streak begins behind the ear and runs back about half the length of the neck, separating the yellow of the throat from the brown of the upper side. Entire border of upper lip, chin, throat, and anterior part of chest whitish to golden yellow; remainder of underside brown. Fore and hind legs the brown of adjacent upper parts; fore feet slightly darker than remainder of fore leg. Tail very dark brown, almost black.

Measurements of two adult females, one from Sandakan and the second from Bukit Kretam, are: head and body 420, 415; tail 345, 310; hind foot 85, 85. Skull measurements of the Bukit Kretam specimen are: greatest length 81.5, condylobasal length 79.6, zygomatic breadth 46, upper tooth row (C-M¹) 25. The weight of this individual was 1,000 grams. Chasen and Kloss give the condylobasal lengths of six adult males as 82.2 (80.5–84.6).

According to Hose (1893) the marten is found up to an altitude of 2,000 feet, but we have specimens from as high as 5,000 feet on the Kelabit Plateau in Sarawak. Banks (1931) states that it "is mostly arboreal, generally to be seen high up in the tops of the tallest trees but apparently descends to the ground at times." The same author observed one on a sand-bank beside a stream one evening. Our Bukit Kretam specimen was shot in primary forest, about 8 feet high in a tree, during the morning hours. Hose says it spends the day in the holes of hollow trees, coming out to feed about three hours before sundown.

There is little information on the food of the marten in Borneo. The stomach of our Bukit Kretam specimen contained the remains of a small brachyurid decapod crustacean, and the label on a specimen from the Kelabit Plateau reads "Food: honey, grubs, and a few round worms and bugs." In India this species has been observed eating nectar from rhododendron flowers (Muir, 1916, *Jour. Bombay Nat. Hist. Soc.* 24: 589).

Specimens examined.—Bukit Kretam (1), Sandakan mi. 8 (1 skin only). Chasen and Kloss record it from Bettotan and Rayoh.¹⁵

Mustela nudipes leucocephala Gray.

Weasel.

Gymnopus leucocephalus Gray, 1865, Proc. Zool. Soc. London, 1865: 119.—Borneo.

Mustela nudipes leucocephala Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 14.

A large, long-haired weasel with a very bushy tail. Color bright golden brown above and below. Head white or cream color. A narrow buff-colored stripe begins at the occiput and runs along the midline to the middle of the back, gradually tapering to an acuminate point; this stripe may be very faint, and occasionally is entirely wanting. Hands and feet light brown, without the golden wash. Basal part of tail colored like back; distal half to one third golden buff.

Chasen and Kloss give the measurements of a female from Bettotan as: head and body 320, tail 215, hind foot 49; skull, condylobasal length 55, zygomatic breadth 28.2, upper molar row 13.

¹⁵ Pocock (*Proc. Zool. Soc. London* 1936: 549) records a specimen in the British Museum from "Teutong River, N. Borneo." The Tutong River is in Tutong District, Brunei, not in North Borneo.

Nothing is known of the habits of this animal. The Museum has specimens from altitudes up to 3,700 feet in Sarawak.

Specimens examined.—Kalabakan River (1 skin without skull). Chasen and Kloss record a single specimen from Bettotan.

***Aonyx cinerea cinerea* Illiger.**

Clawless Otter.

Lutra cinerea Illiger, 1815, Abh. Akad. Wiss. Berlin, 1804–1811: 90.—near Batavia, West Java; Chasen, 1940, Bull. Raffles Mus., 15: 93.

Aonyx cinerea cinerea Ellerman and Morrison-Scott, 1951, Checklist Palaearctic & Ind. Mam., p. 278.

A small otter with minute claws on all the digits, feet small and not extensively webbed, and a small naked muzzle. Color dark brown above, slightly lighter below; in a specimen from near Sandakan the entire pelage has a rufous cast. A very few isolated white hairs are scattered through the pelage, too few to affect the general color. The edge of the upper lip and the chin are buffy, grading into buffy brown on the throat, cheeks, and sides of neck.

I have no specimens with measurements, but Chasen and Kloss give the following measurements for six adult males from Bettotan: head and body 409 (360–440), tail 246 (225–270), hind foot 89 (85–93). Skull measurements of the same six individuals are given as: condylobasal length 82.2 (80.5–84.6), zygomatic breadth 56.8 (54.2–60), upper cheek teeth 25 (24.2–26). Specimens in Chicago Natural History Museum show that this animal occurs in Borneo from sea-level to altitudes of at least 3,500 feet. Little is known of their habits. Banks (1931) says they occur from the sea shore back to the small side streams of rivers, “sometimes solitary, sometimes in families of five or six.” Abbott (in Lyon 1909, p. 486) says “they doubtless feed upon shellfish, among other things, and I know they eat crabs.”

Specimens examined.—Sandakan mi. 8 (1 skin without skull), Kalabakan River (1). Chasen and Kloss record it from Bettotan, Lyon (1909, plate 36) from the Kinabatangan River, and Allen and Coolidge (1940) from Tuaran and the Kalabakan River.

***Lutra sumatrana* Gray.**

Hairy-nosed Otter.

Barangia sumatrana Gray, 1865, Proc. Zool. Soc. London, 1865: 123.—Sumatra.

Lutra lovii Günther, 1876, Proc. Zool. Soc. London, 1876: 736.—Borneo opposite Labuan Island.

Lutra sumatrana Anderson, 1878, Zool. Res. Yunnan, vol. 1, p. 206.

An otter with well developed claws on all the digits, feet large and extensively webbed, and with the nose-pad covered with short hairs. Color dark brown above, slightly lighter below. Upper lip, chin, throat, cheeks, and sides of neck white or yellowish.

I have seen no North Bornean specimens of this otter. North Borneo records are: Mengalong River, opposite Labuan (Günther, 1876), and Sandakan (Pocock, 1941, Fauna Brit. India, Mammalia, vol. 2, p. 290).

***Mydaus javanensis lucifer* Thomas.**

Teledu. (Plate 18).

Mydaus lucifer Thomas, 1902, Ann. Mag. Nat. Hist., (7) 9: 442.—Borneo opposite Labuan Island.

Mydaus javanensis lucifer Chasen, 1940, Bull. Raffles Mus., 15: 92.

Small, heavy-bodied, with a long pig-like snout and a very short tail. Color black above and below. A broad white patch on the crown and neck is continued into a narrow mid-dorsal stripe that extends to the tip of the tail. The extent of the white area

is extremely variable. In a specimen from Sandakan the patch on the crown and nape is narrow and the dorsal stripe is absent except for a very narrow line on the rump, which is interrupted by black at the base of the tail; the terminal tail hairs are white. In a specimen from the Sapagaya Forest Reserve the whole head is white to a point just in front of the ears, the white continued over the forehead into a broad crown and nuchal patch, which in turn continues into a broad mid-dorsal stripe running the length of the body and tail; there is even some white on the feet of this individual. Both specimens have a whorl of hairs on the occiput.

Measurements of an old adult female and a subadult male are: head and body 434, 370; tail 38, 34; hind foot 70, 68. Skull measurements of these two individuals are: total length 90, 86; condylobasal length 87, —; zygomatic breadth 43, 42; palatal length 47, 46; upper toothrow (C-M¹) 24, 23.5. The adult female weighed 1,275 grams.

This animal occurs up to an altitude of 3,500 feet on the Kelabit Plateau in Sarawak. Its habits are not well known. Two of our specimens were shot on the ground at night in old logged forest. The third was found dead, also in old logged forest. A fourth individual was encountered at night on a trail in old logged forest in the Sapagaya Forest Reserve. It quickly disappeared under a log and was lost. The odor of this animal is very similar to that of the North American skunk.

Banks (1931) states that *Mydaus*, like the skunks, when molested "raises the tail straight up in the air, turns the head away from the intruder, and may be induced to eject to a distance of six inches or more nearly a teaspoonful of pale greenish fluid." According to the same author it lives in shallow holes in the ground, dug either by itself or by porcupines. During digging in captivity the pig-like snout was used to loosen the earth "at the apex of its pointed diggings."

The stomach of one of our specimens, collected in old logged forest, was well filled with large earthworms and contained nothing else. The earthworms were in intact segments 45–90 mm. in length.

Specimens examined.—Sandakan mi. 5 (1); Sapagaya Forest Reserve (1 skin and skull, 1 skeleton only). The type came from the mainland opposite Labuan.

CIVETS AND MONGOOSES

Family VIVERRIDAE

Borneo has nine genera of Viverridae, which gives it one of the richest viverrid faunas in the world. One Malaysian genus (*Viverricula*) is absent from Borneo but is present on the mainland, Sumatra, and Java.

I find no published records of *Prionodon*, *Paguma*, or *Cynogale* from North Borneo, and we did not collect specimens of these three genera. They may be expected to occur in the colony, however, and have therefore been included here.

The Bornean civets have undergone considerable adaptive radiation, in both locomotor and feeding habits. The most generalized form is *Viverra*, the common civet, a nocturnal non-climbing animal that feeds on small vertebrates and insects. The limbs are specialized for cursorial locomotion in *Viverra*; the feet are digitigrade and the metapodials elongated, as in the cats. Except for the otter civet, the other Bornean civets are more or less arboreal. *Cynogale*, the otter civet, is an otter-like aquatic form.

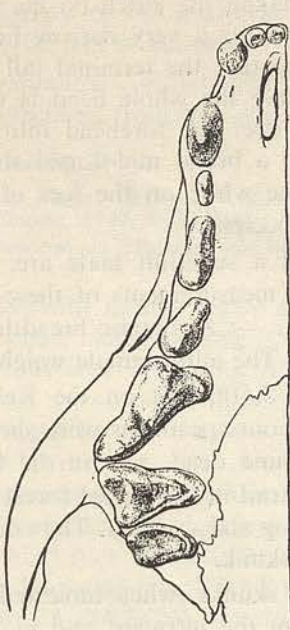
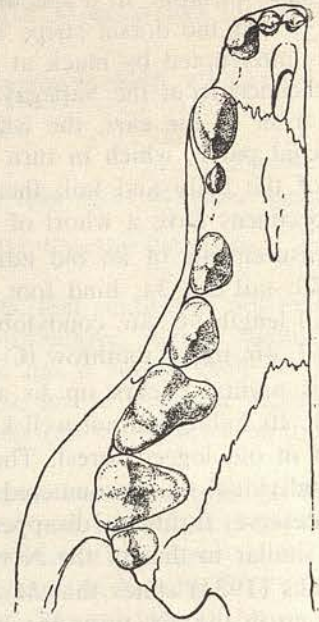
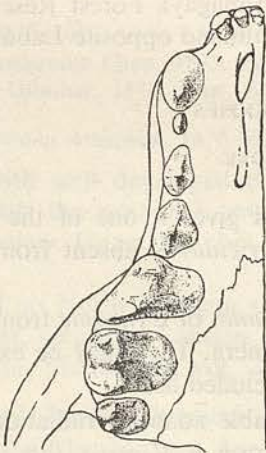
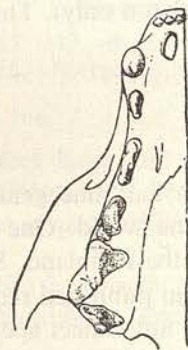
*Viverra tangalunga tangalunga**Paguma larvata ogilbyi**Paradoxurus hermaphroditus philippinensis**Prionodon linsang gracilis*

Figure 18. Upper dentition of Bornean civets, arranged to show adaptive radiation away from the generalized sectorial dentition of *Viverra*.

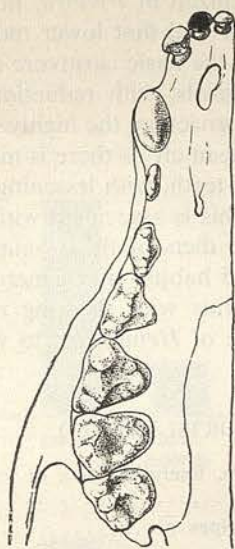
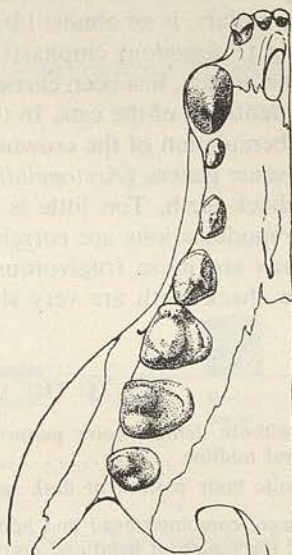
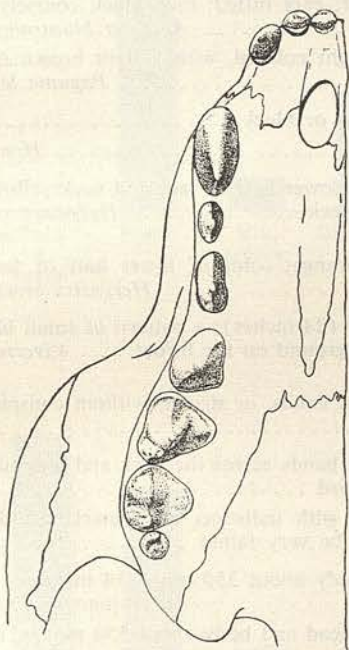
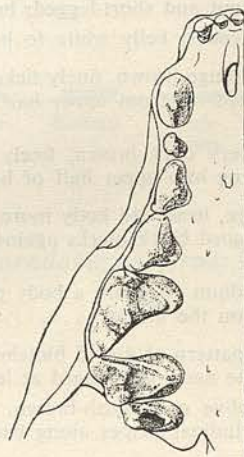
*Hemigalus derbyanus boiei**Arctogalidia trivirgata stigmatica**Arctictis binturong penicillatus**Herpestes brachyurus rajah*

Figure 19. Upper dentition of Bornean civets, arranged to show adaptive radiation away from the generalized sectorial dentition of *Viverra*.

The dentition (fig. 18, 19) is also most generalized in *Viverra*, in which the blade-like shearing function of the fourth upper premolar and first lower molar, coupled with crushing rear molars, is an almost ideal example of the basic carnivore dental adaptation. In the linsang (*Prionodon*) emphasis of the carnassials, with reduction of the crushing function of the molars, has been carried farther, approaching the highly specialized purely flesh-cutting dentition of the cats. In the other Bornean civets there is more or less broadening and tuberculation of the crowns of the cheek teeth, with lessening of the carnassial function. In some genera (*Arctogalidia*, *Arctictis*) this is associated with reduction in the size of the cheek teeth. Too little is known of the diets of these animals to show how closely these modifications are correlated with food habits. In a general way the broad-crowned forms are more frugivorous than are forms with shearing teeth (fig. 20). In *Cynogale* the cheek teeth are very similar to those of *Hemigalus*, to which it is closely related.

KEY TO THE CIVETS OF NORTH BORNEO

- 1 a. Body without definite color pattern; color uniform, finely grizzled, or at most darker along dorsal midline 2
- b. A definite body pattern of dark spots, bars, or stripes 6
- 2 a. Size large, combined head and body length more than 610 mm. (24 inches); tail more than half the length of head and body 3
- b. Size medium or small, head and body less than 550 mm. (21½ inches); tail one half or less than one half head and body length 4
- 3 a. General color black coarsely ticked with buff; ears tufted; face black coarsely ticked with white or buff *Arctictis binturong penicillatus*
- b. General color brown; ears not tufted; face light colored, with a light brown mask on side of muzzle; tip of tail usually white *Paguma larvata ogilbyi*
- 4 a. Body stout and short-legged; belly dark brown or black 5
- b. Body slender; belly white to buff *Hemigalus hosei*
- 5 a. Color orange brown, finely ticked with yellow; lower half of face and neck yellowish, sharply marked off from upper half of head and neck *Herpestes semitorquatus semitorquatus*
- b. Color very dark brown, finely ticked with orange; color of lower half of face and neck grading into upper half of head and neck *Herpestes brachyurus rajah*
- 6 a. Size large, head and body more than 610 mm. (24 inches); a pattern of small black spots; 3 U-shaped black marks against a white background on the throat *Viverra tangalunga tangalunga*
- b. Size medium or small; a body pattern of spots, bands, or stripes, without conspicuous markings on the throat 7
- 7 a. A bold pattern of 4 or 5 blotches or transverse bands across the back and longitudinal stripes on the neck; tail ringed at least at basal third 8
- b. Color olive or grayish-brown, often mottled with indistinct dark markings; three narrow longitudinal stripes along back (these may be very faint) 9
- 8 a. Tail ringed to the tip; size small, head and body about 350 mm. (14 inches) *Prionodon linsang gracilis*
- b. Tail ringed only on basal third; size medium, head and body about 550 mm. (21½ inches) *Hemigalus derbyanus boiei*
- 9 a. Tail about three-fourths the length of head and body; usually a narrow dark longitudinal line between the eyes *Paradoxurus hermaphroditus philippinensis*
- b. Tail about a fourth longer than head and body; usually a narrow white median line on the nose *Arctogalidia trivirgata stigmatica*

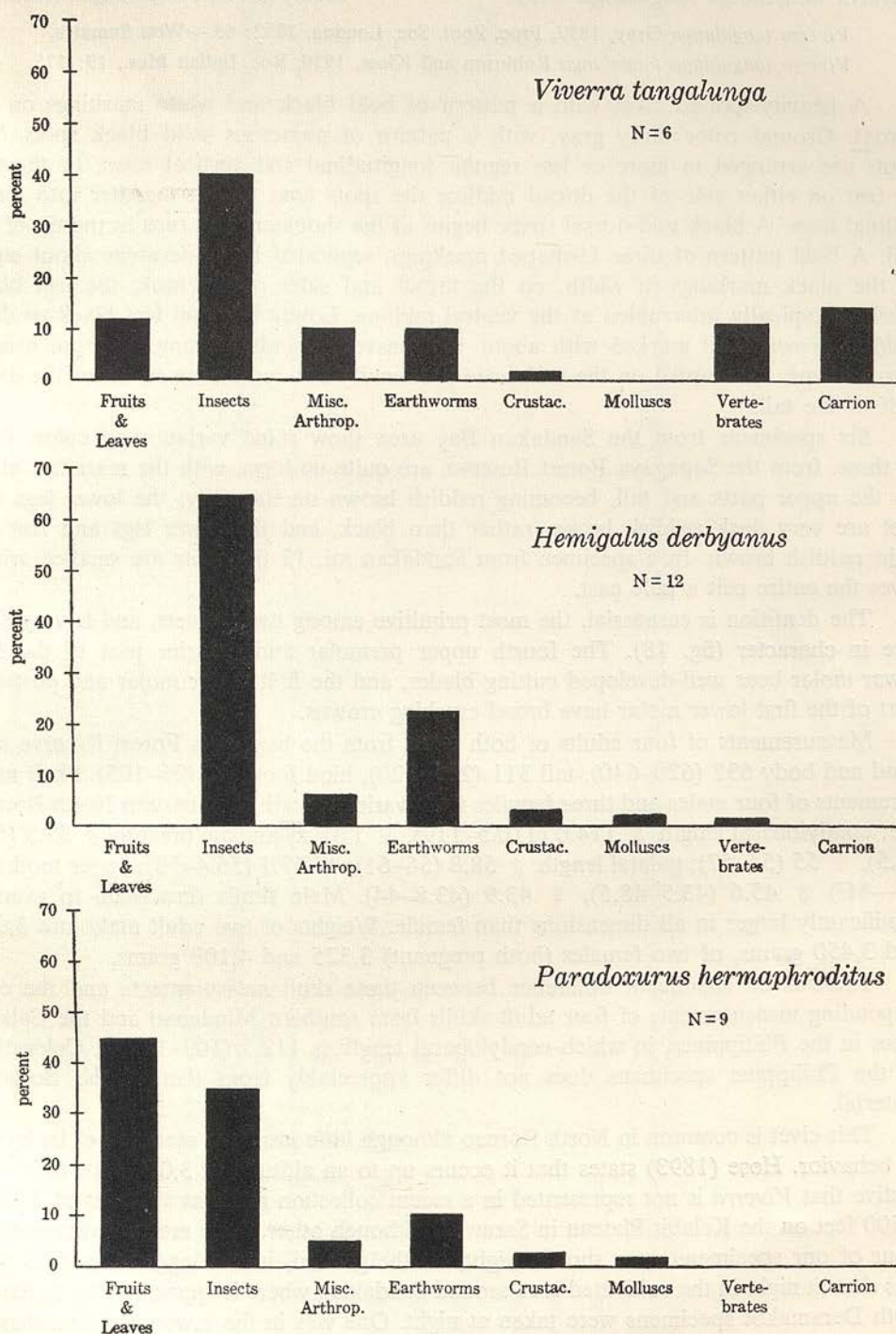


Figure 20. Diet in three genera of Bornean civets, based on analysis of stomach contents. *N* refers to number of stomachs examined (see Tables).

***Viverra tangalunga tangalunga* Gray.**Malay Civet, *Tangalong*. (Plate 19).*Viverra tangalunga* Gray, 1832, Proc. Zool. Soc. London, 1832: 63.—West Sumatra.*Viverra tangalunga tangalunga* Robinson and Kloss, 1930, Rec. Indian Mus., 19: 175.

A heavily-spotted civet with a pattern of bold black and white markings on the throat. Ground color buffy gray, with a pattern of numerous solid black spots. The spots are arranged in more or less regular longitudinal and vertical rows. In the row or two on either side of the dorsal midline the spots tend to run together into longitudinal lines. A black mid-dorsal stripe begins at the shoulders and runs to the tip of the tail. A bold pattern of three U-shaped markings, separated by white areas about equal to the black markings in width, on the throat and sides of the neck; the last black marking typically interrupted at the ventral midline. Lower legs and feet black or dark reddish brown. Tail marked with about 15 transverse bands running out from a mid-dorsal stripe, interrupted on the underside proximally but continuous in about the distal half of the tail.

Six specimens from the Sandakan Bay area show some variation in color. Four of these, from the Sapagaya Forest Reserve, are quite uniform, with the markings black on the upper parts and tail, becoming reddish brown on the belly; the lower legs and feet are very dark reddish brown rather than black, and the lower legs and feet are light reddish brown. In a specimen from Sandakan mi. 12 the spots are smaller, which gives the entire pelt a pale cast.

The dentition is carnassial, the most primitive among living civets, and is very dog-like in character (fig. 18). The fourth upper premolar and anterior part of the first lower molar bear well-developed cutting blades, and the first upper molar and posterior part of the first lower molar have broad crushing crowns.

Measurements of four adults of both sexes from the Sapagaya Forest Reserve are: head and body 632 (620–640), tail 311 (285–320), hind foot 101 (96–105). Skull measurements of four males and three females from various localities in eastern North Borneo are: condylobasal length ♂ 114.0 (110.5–119), ♀ 110; zygomatic breadth ♂ 57.3 (55–58.5), ♀ 55 (54–57); palatal length ♂ 58.8 (56–61), ♀ 57.1 (56.4–58); upper toothrow (C—M²) ♂ 45.6 (43.5–48.5), ♀ 43.9 (43.8–44). Male skulls thus seem to average significantly larger in all dimensions than female. Weights of two adult males are 3,025 and 3,450 grams, of two females (both pregnant) 3,325 and 4,100 grams.

There is no significant difference between these skull measurements and the corresponding measurements of four adult skulls from southern Mindanao and the Calamianes in the Philippines, in which condylobasal length is 112.5 (109–119.4). Coloration of the Philippine specimens does not differ appreciably from that of the Bornean material.

This civet is common in North Borneo although little has been recorded of its habits or behavior. Hose (1893) states that it occurs up to an altitude of 3,000 feet. It is suggestive that *Viverra* is not represented in a recent collection made at altitudes of 3,000–5,500 feet on the Kelabit Plateau in Sarawak, although other civets are well represented. Four of our specimens were shot at night, on the ground, in old logged forest. A fifth was shot at night in the cultivated area around Sandakan, where it appears to be common. Both Deramakot specimens were taken at night. One was in the lowermost branches of a mature fruit tree, 20 feet above ground; the other was on the ground in primary forest.

No.	Fruits and Leaves	Insects except Termites	Earthworms	Spiders	Pedipalps	Centipedes and Millipedes	Crabs	Vertebrates	Carion	Termites
	%	%	%						%	%
68704	60	20	15	1	1	..	..	..	..	..
68705	..	25	30	2	..	..	..	1 lizard	..	..
68706	..	40	..	2+	..	2	..	1 snake 1 frog	..	25+ individuals
68707	..	50	5	..	..	..	1	..	..	35
85115	..	..	..	1	..	..	..	..	95	..
85116	10	10	..	1	..	..	..	..	..	80

Diet of *Viverra zibethica*. Analysis of contents of 6 stomachs. Percentage figures are rough estimates of percent of total bulk of food present in stomach. Other figures refer to individual occurrences.

Banks states that the tangalong is terrestrial, and that captives were "poor climbers" and "less arboreal" than other civets. There is a mane of erectile hairs down the centre of the back; according to Banks this is not evident in all live individuals.

Stomach contents of 6 individuals were examined: 4 from the Sapagaya Forest Reserve and 2 from Deramakot. The resulting food data are summarized in the accompanying table. Insects and other arthropods are the dominant food items, accounting for about half the total bulk of the food. Termites are evidently devoured greedily when available. Earthworms, present in half the stomachs, figure less prominently than in the diet of *Hemigalus*. Vertebrates occurred in only two stomachs: a skink (*Sphenomorphus*?) with a snout-vent length of about 60 mm. in one, and in a second a burrowing snake (*Calamaria brachyura*), in intact pieces 40–60 mm. long, and a small frog. One individual, shot in camp, had gorged itself on refuse from the skinning table. Vegetable matter was present in only two stomachs: in one the bulk of the stomach contents consisted of 25 endocarps of an unidentified fruit, each about 20 mm. long; and a second stomach contained a quantity of unchewed pieces, 30–40 mm. long, of a narrow, parallel-veined leaf. Fragments of dead leaves and twigs, evidently ingested accidentally, were present in all stomachs.

The nature of the food indicates that *Viverra* forages on the forest floor, devouring anything of suitable size that comes its way. Some food items are rather astonishing: a very hard and extremely spiny walking stick 85 mm. long, and a 120-mm. centipede, for example.

Food items are in general less thoroughly fragmented than comparable items from stomachs of *Hemigale* and *Paradoxurus*. The skinning table refuse that filled one stomach consists of fair-sized chunks of meat, none containing bones, that apparently had been bolted entire, plus the bones of a fish. Banks lists various mammals, birds, and reptiles that were eaten by captive individuals.

The two females collected by us, on July 20 and July 23, were both pregnant. Each contained two young.

Specimens examined.—Total 8. Sandakan mi. 8 (1), Sandakan mi. 12 (1), Sapagaya Forest Reserve (4), Deramakot (2). Allen and Coolidge record this civet from Abai, and Chasen and Kloss from Samawang and Bettotan.

***Prionodon linsang gracilis* Horsfield.**

Linsang.

Felis gracilis Horsfield, 1821, Zool. Researches Java, no. 1, pl.—Blambangan, East Java.

Prionodon linsang gracilis Robinson and Kloss, 1919, Jour. Fed. Malay States Mus., 7: 264.

A small long-necked civet with tail about as long as head and body, characterized by a bold pattern of two longitudinal stripes on the neck and five transverse bars across the back. The tail is ringed throughout its entire length.

Ground color buff, the markings chocolate brown. The facial pattern consists of a brown muzzle continued into a narrow ring around the eye, which in turn continues into a cheek stripe running backward and downward below the ear. On the neck there are four longitudinal stripes, the median pair broader and the light interspace between them bearing several small irregular spots. Five transverse bands on the back, the last narrow and broken and tending to fuse with the first caudal ring. The transverse bands may or may not be inter-connected at their lateral ends by a longitudinal stripe, in line with the median neck stripes, that is more or less interrupted by extension of the light interspaces separating the transverse bands. A series of spots, tending to fuse into a longitudinal stripe, on the flank. Tail ringed throughout its length with alternate brown and buff, the brown rings nearly twice as wide as the buff. Throat and belly buff to cream color.

The dentition is highly carnassial and cat-like, except that the canines are small and slender (fig. 18). The fourth upper premolar bears a long cutting blade, the first upper molar is much reduced, and the second upper molar is absent.

No flesh measurements of any North Bornean individual are known. A specimen from Kuching, Sarawak, has the following collector's measurements: head and body 350, tail 345, hind foot 54.

The habits of this civet are unknown. I have seen no specimen from North Borneo; the above description was drawn up from a series of four skins from Sarawak. Banks states that a captive individual was a good climber. The related *Prionodon pardicolor*, of eastern India and Burma, is "equally at home on trees and on the ground; it breeds and dwells in the hollows of decayed trees . . . and preys chiefly on small birds, which it is wont to pounce upon from the cover of the grass." (Pocock, 1939, *Fauna Brit. India, Mammalia*, vol. 1, p. 339).

Locality records.—Pocock (1933: 976) records a specimen from Mt. Kinabalu, collected by Everett.

***Paradoxurus hermaphroditus philippinensis* Jourdan.** Palm Civet, *Musang*. (Plate 19).

Paradoxurus philippinensis Jourdan, 1837, C.R. Acad. Sci. Paris, 5: 523.—Philippine Islands.

Paradoxurus sabanus Thomas, 1909, Ann. Mag. Nat. Hist. (8) 3: 376.—Spitang [Sipitang], North Borneo.

Paradoxurus hermaphroditus philippinensis Pocock, 1934, Proc. Zool. Soc. London, 1934: 654.

A small short-legged civet with tail slightly shorter than the length of head and body. In North Borneo *Paradoxurus* closely resembles *Arctogalidia* in size and color; in addition to its shorter tail, *Paradoxurus* may usually be distinguished by having a narrow dark line running along the midline between the eyes, whereas in *Arctogalidia* there is usually a narrow white line in this area. The teeth, of course, are very different.

Ground color olive brown, often somewhat mottled with indistinct dark markings. The hairs are dark at the base, and the mottling results from the darker basal parts showing through. Along the midline of the back there are three narrow black stripes, slightly irregular and often broken, and usually visible only when the pelage is viewed from the rear, running from the occiput to the base of the tail. The face mask is very indistinct in North Bornean specimens, due to darkening of the normally buff-colored areas on the face. Ears and occipital area very dark brown or black. Lower legs and feet very dark brown or black. Tail uniformly very dark brown to the tip.

There is much individual variation in color and pattern in this civet, but specimens from northeastern North Borneo are uniformly darker than specimens from Sarawak. An individual from Sandakan mi. 8 is erythristic, with no indication of dorsal stripes, although the face mask is well developed.

In the dentition (fig. 18) the carnassials P_4/M_1 , the cutting teeth of the typical carnivores, have a basically blade-like structure, although far less so than in *Viverra*. In *Paradoxurus* the rear premolars and molars are broadened from side to side to produce square crushing teeth, presumably in adaptation to a less carnivorous diet. This is most conspicuous in P_4 , in which the protocone is enlarged and a well-developed postero-internal cingulum is present (fig. 18).

Measurements of four adults of both sexes from the Sapagaya Forest Reserve and Sandakan areas are: head and body 455 (420–495), tail 359 (330–395), hind foot 75 (74–76). The mean tail—head and body ratio is 0.80. Skull measurements of seven

specimens from eastern North Borneo are: condylobasal length 96.1 (92.4–99.6), zygomatic breadth 55.6 (51.5–60.5), palatal length 43.7 (41–45.9), upper tooththrow (C–M²) 35.5 (33–36.8). Our series reveals no sexual dimorphism in skull measurements. Weights of three adult males were 1,950, 2,175, and 2,500 grams; of three females 1,650, 1,700, and 2,000 grams.

A series of 26 *Paradoxurus h. philippinensis* from the Philippines (Palawan and Calamianes 16, Mindanao 6, Negros 4) exhibits a wide range of coloration. The ground color of the upper surface ranges from dark brown to buffy gray, the brown phase predominating but with complete gradation between the extremes. Sides and underparts paler than back and with a silvery overlay. A pattern of three broken longitudinal stripes on the back, relatively obscure in all and obsolete in five individuals. Crown of head dark in all specimens, varying from brown to black; in some (but not all) of the palest individuals these brown hairs are tipped with buff. Face mask more extensive and more strongly contrasted in paler individuals. Feet and tail range from uniform pale brown to dark brown; tail brown to the tip in all individuals. One specimen from Negros is uniform dark brown all over, with no mask or dorsal pattern and no difference between the color of feet and tail and that of the rest of the body.

The presence of a whorl on either side of the neck, with the hair on the sides and nape of the neck directed forward, has been used to distinguish the species *zeylonensis* and *jerdoni* from the species *hermaphroditus*. In the Philippine series more than half the individuals have neck whorls, ranging from small whorls not affecting the general backward hair slope, through whorls associated with hair sloping toward the dorsal midline to form a median crest on the occiput and anterior neck, to individuals in which the hair on the occiput and anterior neck slopes forward.

Skull measurements of 16 fully adult animals from this series, compared with 7 specimens from North Borneo are given in the accompanying table.

	Philippines (males)	Philippines (females)	Borneo (both sexes)
Number of specimens ...	8	8	7 ¹⁶
Greatest length ...	97.7 (95.4–101.8)	97.1 (92.3–100.2)	—
Condylobasal length ...	96.6 (94.6–99.9)	96.5 (92.2–100.2)	96.1 (92.4–99.6)
Zygomatic breadth ...	57.6 (54.4–59.6)	55.0 (51.8–59.7)	55.6 (51.5–60.5)
Palatal length ...	45.0 (42.5–47.8)	45.9 (43.4–47.0)	43.7 (41–45.9)
Breadth M ¹ –M ¹ ...	34.5 (33.0–36.9)	34.4 (33.4–35.8)	33.6 (31.2–37.3)
Length C–M ² ...	36.7 (34.3–38.6)	36.7 (35.3–38.5)	35.5 (35–36.8)

These data do not confirm the conclusion of Pocock (1934) that the Bornean Palm civet is indistinguishable from the Philippine form. The Bornean form is smaller than the Philippine form as Thomas stated when he proposed the name *sabanus* for it.

The palm civet is one of the common Bornean civets. All specimens collected by us were taken at night, in both primary and old logged forest.

It was found both on the ground and in trees in the middle story of the forest, but appeared to be essentially arboreal.

16. Two skulls minus occipital region.

No.	Fruits and Leaves	Orthoptera	Coleoptera	Lepidopteran Larvae	Earthworms	Spiders	Crabs	Molluscs
	%				%			
68710	100	..	..	..	..	..	..	..
68712	95	..	2	..	..	..	1	1
68713	..	..	..	1	..	1	..	..
85111	..	1	..	..	..	..	..	..
85112	..	1	1	..	40	..	..	1
85113	trace	1	..	..	1	..	1	..
85933	100	..	..	..	..	..	..	..
85934	30	1	1	..	..	..	..	..
85935	60	40%	..	..	..	..	..	..

Diet of *Paradoxurus hermaphroditus*. Analysis of contents of 9 stomachs. Percentage figures are rough estimates of percent of total bulk of food in stomach. Other figures refer to individual occurrences.

The diet of this animal is not well known. Banks states that "fruit or meat form the food." Stomachs of 9 individuals collected by us were examined: three from the Sapagaya Forest Reserve, three from Kalabakan, and three from Deramakot. The resulting food data are summarized in the accompanying table. Fruits and leaves accounted for about 45 per cent, and arthropods for another 45 per cent, of the total bulk of the food. Thus these two together constituted about 90 per cent of the diet of the nine palm civets examined. The fruits were of various kinds, and were present in five stomachs. Leaves were present in one stomach only, which contained nothing else. They consisted of 18 unchewed pieces, each 30–40 mm. long, of narrow parallel-veined leaves. The arthropods were almost exclusively orthopterans and beetles. Earthworms evidently figure less prominently than in the diet of *Viverra*, and much less so than in the diet of *Hemigalus*. The molluscs consisted of one prosobranch land snail (*Cyclotus pterycycloides*) and one arboreal pulmonate snail (*Helicarionidae*). No vertebrate remains appeared in any of the stomachs examined, nor were any termites found. In general, the diet of *Paradoxurus* appears to be much less varied than that of *Viverra* or *Hemigalus*.

Of six females, collected between May 6 and August 10, none was pregnant.

Specimens examined.—Total 12. Sapagaya Forest Reserve (4), Sandakan mi. 8 (1), Deramakot (4), Kalabakan (3).

***Arctogalidia trivirgata stigmatica* Temminck.**

Small-toothed Palm Civet.

Paradoxurus stigmaticus Temminck, 1853, Esquisses Zool. Côte de Guinée, Mamm., p. 121.—Dusun River, S. Borneo.

Arctogalidea trivirgata stigmatica Pocock, 1933, Proc. Zool. Soc. London, 1933: 996; Van Bemmelen, 1952, Beaufortia, 2, no. 16, p. 31 (systematic review of genus).

A small slender short-legged civet with a long tail. In North Borneo *Arctogalidea* closely resembles *Paradoxurus* externally, but differs conspicuously in having a tail about a fourth longer than head and body. There is typically a light median stripe on the nose, but this appears to be sometimes indistinct or even absent in specimens from North Borneo. The color pattern consists of three narrow black lines, closely spaced along the midline of the back, against a lighter background; the stripes may be indistinct or even absent.

Ground color olive brown to grayish brown; underfur of back and sides reddish brown. Three narrow dark stripes, regular and uninterrupted, begin at the occiput and extend to the base of the tail; these are conspicuous in all three specimens from North Borneo, but are indistinct or even wanting in specimens from Sarawak. Head, including ears, darker than body; in two North Bornean specimens there is an indistinct light median stripe on the nose, but this is wanting in a third. Lower legs and feet colored like face. Tail dark brown or black, lighter at base. The Bornean *stigmatica* is smaller than the typical *trivirgata* from the mainland.

The skull is characterized by long postorbital processes and a long mesopterygoid fossa, the anterior half roofed over. The dentition differs strikingly from that of *Paradoxurus* in the region of the rear premolars and first molar, especially in the upper jaw. In *Arctogalidia* these teeth are greatly reduced to form cylindrical, almost peg-like, crushing teeth (fig. 19). Unfortunately too little is known of the food habits of this animal to permit comparison with the diet of *Paradoxurus*.

Measurements of an adult male from Bukit Kretam are: head and body 520, tail 630, hind foot 91. Tail/head and body ratio 1.21. Skull measurements of this and an adult female from Deramakot are: greatest length 110, 112.5; condylobasal length 108,

100; zygomatic breadth 59, 57; palatal length 62, 57.5; upper toothrow (C—M²) 40.5, 38.9. Weight of the adult male 2,350 grams, of the adult female 2,000 grams.

Arctogalidia appears to be less common than *Paradoxurus* in North Borneo. It is extremely arboreal, among the most arboreal of Bornean civets. Two specimens collected by us were shot from trees in heavy primary forest, one from the crown of a large fig tree at 11:00 a.m., the other from an unidentified tree at night. The Deramakot specimen was shot from a fruit tree in secondary growth, 20 feet above ground. Banks states that a captive "sometimes used to walk upside down on the wooden roof of its cage" by clinging to the cracks between the boards.

The diet of this civet is varied. According to Banks "it will eat almost anything" (in captivity), including fruit, various birds, frogs, and snakes. Of two stomachs collected by us, one contained large numbers of a pulpy fruit, amounting to about 90 percent of the total bulk of food; one large orthopteran, about 50 mm. long, in fragments; and one head capsule of an ant. The other stomach contained two fruit endocarps, 15 mm. long, and pieces of fruit pulp. Shortridge (in Wroughton, 1915, *Jour. Bombay Nat. Hist. Soc.* 23: 711) states that the stomachs of specimens collected by him in Burma contained remains of squirrels, and that all palm civets "live largely on squirrels."

Specimens examined.—Bukit Kretam (1), Sapagaya Forest Reserve (1 juvenile), Deramakot (1).

***Paguma larvata ogilbyi* Fraser.**

Masked Palm Civet.

Paradoxurus ogilbyi Fraser, 1846, Zool. Typica, no. 10.—Type locality unknown.

Paguma larvata ogilbyi Pocock, 1934, Proc. Zool. Soc. London, 1934: 679.

A large civet with tail slightly shorter than head and body, characterized by its yellowish-white face and absence of body pattern.

General color reddish brown, becoming very dark brown, almost black, on shoulders and nape. The underfur is grayish yellow. Ears dark brown; face yellowish white, washed with brown on muzzle and around eyes; throat dirty yellowish brown. Belly paler than back. Lower legs and hands and feet very dark brown, almost black. Tail colored like body at base, terminal half dark brown or black; tip often yellowish white.

The dentition (fig. 18) is very similar to that of *Paradoxurus*, but has a somewhat less crushing character. On P⁴ the protocone is not enlarged as in *Paradoxurus*, and the postero-internal cingulum is wanting.

No accurate measurements are available for Bornean specimens. Hose (1893) gives "head and body 27 inches; tail 20 inches."

Nothing is known of the habits of this animal in Borneo. We did not encounter it in the Sandakan Bay or Dewhurst Bay areas, nor was it seen by the 1956 expedition. Banks states that captives "showed a preference on the whole for bananas as food rather than fish or dead animals." Elsewhere *Paguma* is "omnivorous, feeding partly on vegetable, partly on animal food, including birds and small mammals." (Pocock, 1939, *Fauna British India, Mammalia*, I: 430). Ishiguro (1942, *Mem. Fac. Sci. Agr. Taihoku Imp. Univ.* 23: 200) found the stomach of a Formosan *Paguma larvata* "stuffed almost exclusively with *Vaginula*" (*Laevicaulus alte* Ferussac, an imported systellomatophoran land slug).

Locality records.—Pocock (1934) listed North Bornean specimens in the British Museum from Saiap, Kinabalu, and Spitang (Sipitang).

Arctictis binturong penicillatus Temminck.

Binturong.

Arctictis penicillatus Temminck, 1841, Mon. Mamm., 2: 310.—Java.*Arctictis pageli* Schwarz, 1911, Ann. Mag. Nat. Hist. (8) 7: 636.—Sandakan, North Borneo.*Arctictis binturong penicillatus* Pocock, 1933, Proc. Zool. Soc. London, 1933: 1021.

A very large civet with tail as long as or very slightly shorter than head and body; the tail is very heavy at the base. The binturong is characterized by very coarse black pelage, usually coarsely grizzled, and by a conspicuous tuft of long black hairs on the back of the ear.

General color black above and below, coarsely grizzled—especially on the head and outer sides of the legs—with gray, buff, or foxy red. The grizzling is produced by terminal annulations on the hairs, and varies in color and extent. The facial vibrissae are long and heavy, the longer ones white with black bases, some of the shorter ones black.

The dentition is similar to that of *Paguma*, but is even more reduced (fig. 19). This is especially evident in the upper fourth premolar and first molar. The skull exhibits a characteristic inflation of the frontal region.

Collector's measurements on our adult male are: head and body 648, tail 581, hind foot 118. Skull, condylobasal length 131.7, palatal length 71, zygomatic breadth 74, upper toothrow (C-M²) 41. This individual weighed 7,500 grams.

This species is said to be nocturnal and arboreal (Hose, 1893, Banks, 1931), although our specimen was collected during the day, in primary forest 50 feet above ground. It is the only known civet with a prehensile tail. In captivity it descends head first, using the tail as a brake (Banks, Pocock). According to Pocock, who observed it in the London Zoo, the binturong never leaps, but climbs skillfully though slowly, "progressing with equal ease and confidence along the upper side of branches, or upside down beneath them, the prehensile tail being always in readiness as a help." Banks states that on the ground it is plantigrade, and walks normally instead of hopping as many arboreal forms do.

The diet appears to be largely, but not exclusively, fruit. Captives are fond of bananas, but also eat birds (Banks); or feed upon bread and milk, rice, bananas and other fruits, as well as eggs and fowls' heads (Pocock, 1939, *Fauna Brit. India, Mammalia*, 1: 439). Harrison (1952) examined the stomach contents of an old male trapped in Selangor and found, in addition to fruit seeds and green vegetables, items that obviously came from a garbage dump: orange peel, bones of mutton and fish, most of the bones of a long-dead chicken, and many large dead maggots. The stomach of our specimen contained 33 endocarps, about 25 mm. long, of a pulpy fruit.

Specimens examined.—Kalabakan (1). Schwarz recorded this species from Sandakan and "La Datu" (Lahad Datu?). The "British North Borneo" localities given by Pocock (1933) are all in Sarawak.

Hemigalus derbyanus boiei Müller.

Banded Palm Civet. (Plate 20).

Viverra boiei Müller, 1838, Tijdschr. Nat. Geschied. Physiol., 5: 144.—Southeast Borneo.*Hemigalus derbyanus boiei* Chasen and Kloss, 1931, Bull. Raffles Mus., 6: 11.

A small long-necked civet with tail a little more than half the length of head and body, characterized by a bold pattern of two longitudinal stripes on the neck and five transverse bars across the back. The terminal two thirds of the tail is brown.

Ground color typically buffy gray, varying through buff to bright foxy red. The dark markings are typically chocolate brown, but may be nearly black. The facial pattern consists of a narrow median stripe extending from muzzle to occiput, and a broader cheek stripe passing through the eye. There is a light spot in the cheek stripe

directly above and slightly behind the eye. Two narrow, slightly irregular longitudinal stripes begin at the occiput and end on the shoulder where they expand and turn transversely in L-shape. Behind this there is typically an irregular narrow transverse band, interrupted at the midline, followed on the body by five broad transverse bands uninterrupted at the dorsal midline and wider than the interspaces separating them. Underside typically buff, often washed with orange to bright foxy red. Legs and feet colored like ground color of back. Tail with one or two dark bands proximally, the distal two thirds dark brown.

The hair on the neck slopes forward, with a whorl on either side in front of the shoulder and another whorl about 20 mm. behind each ear.

Variation.—There is much individual variation in ground color, which according to Pocock may range from nearly white to bright orange buff, and in the size and spacing of the dorsal bands. I have a series of eleven skins from the Sapagaya Forest Reserve, and every one of these shows erythrism to some extent. In the most extreme individuals the hind quarters and the entire belly are bright foxy red, and the upper parts, including the dark markings, are strongly washed with red. Four specimens from Deramakot exhibit erythrism to varying degrees, but in none is it as intense as in the Sapagaya specimens. A specimen from Kalabakan is more erythristic than the Deramakot specimens, but less so than the more extreme Sapagaya specimens. A specimen from Sandakan shows no erythrism.

In the dentition the cheek teeth have broad crushing crowns and exhibit a tendency to develop small cuspules (fig. 19). The carnassial character of P^4/M_1 is almost completely lost.

Measurements of 7 adults of both sexes from the Sapagaya Forest Reserve are: head and body 541 (500–565), tail 345 (305–360), hind foot 82 (75–88). The mean tail/head and body ratio is 0.63. Skull measurements of six of these specimens are: condylobasal length 103.9 (101.6–106.0), zygomatic breadth 51 (49–52.5), palatal length 54.8 (54–56), upper toothrow ($C-M^2$) 41.3 (40–42.3). The mean and extreme weights of six adults were 2,333 (2,075–2,575) grams.

This civet appears to be quite common in North Borneo; we collected a greater number of this than of any other species, both in 1950 and in 1956. This was also the most numerous species of civet in the collection made by Chasen and Kloss in 1927. It is exclusively nocturnal, and all our specimens were collected on the ground.

Of 7 adult females collected between May 8 and August 4, none was pregnant.

Stomach contents of 12 individuals were examined: 8 from the Sapagaya Forest Reserve and 4 from Deramakot. These data are summarized in the accompanying table. Saltatory orthopterans and earthworms represent more than 80 per cent of the bulk of the diet. A small grapsid crab was represented in 8 stomachs, small molluscs (one aquatic, 2 terrestrial) in 3, and a larval caecilian (aquatic) in one. Spiders appeared in 9 stomachs, and ants (in considerable numbers in two instances) in 8. Other arthropods were sparingly represented, and a small frog was present in each of two stomachs. The low incidence of beetles is notable, and only one termite was found. No indication of fruit or other vegetable food was found in any stomach. Small dead leaf fragments and pieces of rotted wood and twigs, picked up incidentally during feeding, were numerous.

Hemigalus appears to forage on the forest floor, picking up food items from the surface (earthworms are abundant on the surface of the ground at night). There is no indication that it roots or digs in the ground or in rotted logs. The presence of aquatic forms in the diet suggests that streams or stream banks may be favored.

No.	Saltatory Orthoptera	Coleoptera	Ants	Lepidopteran Larvae	Other Insects	Earthworms	Spiders	Pedipalps	Centipedes and Millipedes	Scorpions	Crabs	Molluscs	Amphibians	Orthoptera and Earthworms
	%					%								%
68716	30	.. 1	.. 3	..	..	50	1	..	..	..	1	1	..	80
68717	80-90	..	..	..	..	Few fragments	1	..	..	..	1	..	..	90
68718	80+	5	50+	..	..	Few fragments	1	..	1	..	1	1	1 small toad	80+
68719	70	..	.. 25+	..	..	20	..	..	1	1	1	..	..	90
68721	30	..	.. 2	..	1 tiny wasp	60	1	..	..	..	1	..	..	90
68723	70-75	..	..	..	..	15	1	..	..	..	..	1	..	85-90
68724	85	2	1	..	..	..	1	.. 4	.. 2	1	1	..	..	85
68725	75	1	1	..	..	Few fragments	2	..	..	..	1	..	..	75+
85106	15	..	.. 4	.. 1	..	85	.. 1	.. 1	.. 1	.. 1	.. 1	..	1 tiny frog	100
85107	60	.. 3	..	..	2 predac. hemip- terans	15	..	..	..	..	..	..	..	75
85108	90	1	..	..	..	Few fragments	..	..	..	..	..	..	..	90+
85109	80	1	6	1	..	..	3	1	..	2	..	..	1 caecilian larva	80

Diet of *Hemigalus derbyanus*. Analysis of contents of 12 stomachs. Percentage figures are rough estimates of per cent of total bulk of food in stomach. Other figures refer to individual occurrences.

Food items were usually, though not always, well fragmented. Heavily armored animals (crabs, pedipalps) were shattered into small pieces. Orthopterans were in larger pieces; and spiders, caterpillars, scorpions, and centipedes apparently were swallowed almost undamaged. Earthworms were cut into sections about 25 mm. long, although one civet contained two earthworms—about 200 mm. long—that were essentially intact, and in another stomach there were undamaged sections up to 90 mm. long.

Banks states that a stomach examined by him contained "the remains of some worms and some ants."

Specimens examined.—Total 17. Sandakan mi. 8 (1), Sapagaya Forest Reserve (11), Deramakot (4), Kalabakan (1). Chasen and Kloss record it from Bettotan.

***Herpestes brachyurus rajah* Thomas.**

Short-tailed Mongoose.

Herpestes brachyurus rajah Thomas, 1921, Ann. Mag. Nat. Hist. (9) 8: 135.—Sarawak.

Herpestes brachyurus dyacorum Thomas, 1921, Ann. Mag. Nat. Hist., (9) 8: 135.—Mt. Dulit, Sarawak.

General color very dark brown, almost black, finely speckled with orange. The individual hairs are light brown at the base and orange-tipped. Head and shoulders slightly paler than back. Hands and feet dark brown, unspeckled. Chin and throat yellowish brown, remaining underparts colored like back. Tail tapering toward the tip, paler than back.

Chasen and Kloss give the measurements of three adults from North Borneo as: head and body 397 (380–425), tail 217 (205–230), hind foot 80 (75–85). Skull measurements are: condylobasal length 88.8 (87.2–92), zygomatic breadth 48.8 (47.5–51.3), palatal length 47.5 (45–48.4), upper molar row 28.2 (27–29.1). Our single North Bornean specimen is subadult (M² not erupted).

Little has been recorded of the habits of the mongoose in Borneo. Our specimen was collected on the ground in primary forest, during the day. The stomach of this individual contained insect fragments including 1 scarab beetle about 22 mm. long and 2 or more orthopterans about 25 mm. long, 1 spider 20–25 mm. in body length, 1 small crab in fragments, and 1 reptile egg 20 mm. long, intact. Banks states that the stomach of one collected on the bank of a stream was "crammed full of cockroaches." Elsewhere mongooses are alert and active creatures, largely terrestrial although able to climb to a certain extent. They are active both by day and night, but are predominantly diurnal, living in burrows dug by themselves or in rock crevices or other natural shelters. They prey upon any small vertebrates they are capable of killing, eggs, and on invertebrates. They are fond of carrion, and also eat small amounts of fruits and roots. There are usually two young in a litter.

Specimens examined.—Kalabakan (1). Chasen and Kloss record this species from the Samawang River and Bettotan.

***Herpestes semitorquatus semitorquatus* Gray.**

Collared Mongoose.

Herpestes semitorquatus Gray, 1846, Ann. Mag. Nat. Hist., 18: 211.—North Borneo, mainland opposite Labuan.

Herpestes semitorquatus semitorquatus Chasen, 1940, Bull. Raffles Mus. 15: 103.

Distinguished from *H. brachyurus* by its paler color, by the pale area on the side of the neck, and by its longer tail.

I have seen no material of this species. Hose (1893) described the color as "rich orange-brown, most intensely rufous on the sides of the body, the back and upper parts of the side being finely marked with yellow, which becomes very indistinct on the

shoulders and outside of the thighs; the fore legs and the lower half of the hind legs are dark purplish-brown. The lower half of the sides of the neck from the extremity of the muzzle backwards below the ear to the front of the shoulder, is a rufous yellow and clearly marked off from the color of the upper part of the neck, which is dark rufous-brown and punctulated, while the underlying neck-band is not."

Hose gives head and body length as 440, tail 270. Chasen and Kloss give the measurements of a specimen from Bettotan as head and body 410, tail 285, hind foot 82; skull: condylobasal length 80, palatal length 42.1, zygomatic breadth 45.2, upper molar row 27.

Locality records.—Recorded by Chasen and Kloss from Bettotan. The type came from the mainland opposite Labuan.

CATS

Family FELIDAE

Five species of cats are known from Borneo. Two of these (*Felis badia* and *Felis planiceps*) have not been recorded from North Borneo, and are not considered here.

The tiger, *Felis tigris* (Malay Peninsula, Sumatra, Java, Bali); leopard, *Felis pardus* (Malay Peninsula, Java, Kangean Islands); golden cat, *Felis temmincki* (Malay Peninsula, Sumatra); and fishing cat, *Felis viverrina* (Java, Sumatra) do not reach Borneo.

KEY TO THE CATS OF NORTH BORNEO

- 1 a. Tail about as long as head and body 2
- b. Tail much shorter than head and body *Felis bengalensis borneoensis*
- 2 a. Size large, head and body more than 600 mm. *Felis nebulosa diardi*
- b. Size medium, head and body less than 550 mm. *Felis marmorata marmorata*

***Felis nebulosa diardi* Cuvier.**

Clouded Leopard. (Plate 21).

Felis diardi G. Cuvier, 1823, Oss. Fossiles, IV, p. 437.—Java (error = Sumatra).

Felis nebulosa diardi Chasen, 1940, Bull. Raffles Mus., 15: 106.

Much the largest Bornean cat, an adult measuring five feet or more from nose to tip of tail. The tail is nearly as long as the head and body. The pattern consists of well marked rosettes on a grayish fawn ground color. The pattern is well shown in Plate 21.

There are no accurate descriptions or measurements of Bornean clouded leopards in the literature, and I have not seen any specimens myself. In the North Bornean specimen the rosettes are open, a black border encircling a much lighter area, and the spaces between the rosettes are relatively wide and irregular. Photographs of two living animals from Sarawak (Selous and Banks, 1935) show much larger and darker rosettes, with the spaces between them very narrow and uniform, giving the effect of a light-colored reticulation on a dark ground color.

Pocock (1939: 252) gives the following skull measurements of an adult female from Padang Pand Jung, North Borneo: total length 141, condylobasal length 129, zygomatic breadth 99, P⁴ 17+, M₁ 12.5. Selous and Banks give the weight of a female as 37 pounds.

This cat inhabits both primary and secondary forest but is commoner in the former (Banks, 1931, 1949). The North Bornean specimen in the possession of G. S. Brown, former Conservator of Forests, North Borneo, was killed on the ground in nipa-mangrove

association on coastal mudflat on 19 March, 1950. Selous and Banks regard this cat as less arboreal than is generally supposed. The North Bornean specimen was shot at 3:00 p.m.; Selous and Banks refer to two instances of clouded leopards bayed on the ground in daylight, and regard it as no more than semi-nocturnal.

The canine teeth are relatively longer in *F. nebulosa* than in any other cat. The G. S. Brown specimen, together with a second individual, had just killed a large male proboscis monkey (*Nasalis*) when discovered. Selous and Banks state that "wild pigs are eaten, remains of which we have been shown and to which the clouded leopard will return time after time until finished." According to Banks (1949) "pigs and monkeys are taken in its wild state and it will follow buffaloes with calves." In captivity a subadult male quickly killed a large pig-tailed macaque (*Macacus nemistrinus*) and rasped the fur from the hind quarters of the monkey before beginning to eat it. The same individual laboriously plucked, with mouth and teeth, the feathers from fowls before beginning to eat them (Selous and Banks). According to Selous and Banks this species does not attack man, but the Malay who killed the G. S. Brown specimen says she turned to attack when approached.

Locality records.—The G. S. Brown specimen was killed at Ulu Sungei Kurapo, near Mumiang, at the northern end of the Trusan Kinabatangan.

Felis marmorata marmorata Martin.

Marbled Cat. (Plate 20).

Felis marmorata Martin, 1836, Proc. Zool. Soc. London, 1836: 107.—Sumatra.

Pardofelis marmorata marmorata Pocock, 1932, Proc. Zool. Soc. London, 1932: 745.

About the size of a domestic cat, with tail nearly or quite as long as head and body. The coat is long, soft, and thick, and the tail bushy. A pattern of about four large, dark-edged blotches on the sides of the body.

Ground color dark reddish brown with a rich buffy wash. The individual hairs are grayish brown with a band of dark brown near the tip and tipped with buff, and the elements of the pattern are produced by selective elimination of the dark brown or buff bands. Head reddish buff, with a complex pattern of black stripes and spots. Four longitudinal black stripes on occiput and neck. Legs and feet reddish buff marked with small black spots. Tail marked with dark brown blotches tending to form longitudinal stripes.

Measurements of an adult female from the Sapagaya Forest Reserve are: head and body 490, tail 495, hind foot 122. Skull: total length 86, condylobasal length 82, zygomatic breadth 66, upper toothrow (C-M¹) 28.5. The weight of this individual was 2,425 grams.

Apparently nothing is known of the habits of this cat. Our specimen was shot on the ground at night in old logged forest. Its stomach contained the undigested remains of a small species of *Rattus*.

Specimens examined.—Sapagaya Forest Reserve (1). This appears to be the only record of this species from North Borneo.

Felis bengalensis borneoensis Brongersma.

Leopard Cat, *Kuching batu*.

Prionailurus bengalensis borneoensis Brongersma, 1935, Zool. Meded. (Leiden), 18: 26.—Rantau, S.E. Borneo.

Felis bengalensis borneoensis Chasen, 1940, Bull. Raffles Mus., 15: 108.

Slightly smaller than a domestic cat, with tail slightly more than half as long as head and body. A leopard-like pattern of spots and blotches on the body.

Ground color a rich reddish buff, darkest along the dorsal midline. A pattern of very dark brown or black spots tending to form three longitudinal stripes along the midline. Typically six longitudinal dark stripes on top of head and neck. Throat and belly white spotted with dark brown. Legs spotted like sides of body. Tail darker above than below, spotted.

Measurements of an adult male from Bukit Kretam are: head and body 435, tail 220, hind foot 115. The skull of this individual is badly broken; the upper toothrow (C-M¹) measures 27.5. The weight of this animal was 1,700 grams.

This is much the commonest Bornean cat, commonly occurring even in the environs of cities. Nevertheless its habits are not well known. Our Bukit Kretam specimen was shot six feet up in a tree in old logged forest at 8:30 p.m. Its stomach was empty.

Specimens examined.—Bukit Kretam (1); Sandakan mi. 12 (1, subadult); Kala-bakan (1, subadult).

Two additional species of small cats are known from Sarawak and parts of Indonesian Borneo but have not been reported from North Borneo. I have seen no material of either species. They are:

***Felis badia* Gray.**

Bay Cat.

Felis badia Gray, 1874, Proc. Zool. Soc. London, 1874: 322.—Sarawak.

***Felis planiceps* Vigors and Horsfield.**

Flat-headed Cat.

Felis planiceps Vigors and Horsfield, 1828, Zool. Jour., 3: 450.—Sumatra.

PROBOSCIDEA

Family ELEPHANTIDAE

***Elephas maximus indicus* Cuvier.**

Asiatic Elephant, *Gaja*.

Elephas indicus Cuvier, 1798, Mem. Inst. (Paris), 2: 21.—India.

Elephas maximus indicus Chasen, 1940, Bull. Raffles Mus., 15: 190.

Elephas maximus borneensis Deraniyagala, 1950, Proc. 5th Ann. Session Ceylon Assoc. Sci., Part III.—Borneo.

It is generally believed that the elephant was introduced by man into Borneo in relatively recent times. This belief is based on the very restricted Bornean distribution of this animal, which is found only in a limited area of North Borneo. Historical records of Bornean elephants go back to Pigafetta's account of Magellan's visit, in 1521, to the northeast coast of what is now called North Borneo. According to Pigafetta, Magellan's party was conveyed to the governor's house on two elephants covered with silk.¹⁷ An elephant phalanx was recently discovered below the neolithic level in the Niah caves in northern Sarawak (von Koenigswald, 1958, *Sarawak Mus. Jour.*, 8: 622). This find indicates that the elephant was present in Borneo in prehistoric times, and that its range was formerly more extensive than at present.

Mature male Bornean elephants are said to have very straight tusks, not curved as in elephants from the mainland (Hubback, 1942, *Jour. Bombay Nat. Hist. Soc.*, 42: 485).

17. Banks (1931) gives a brief review of the early historical accounts.

The distribution of the Bornean elephant has never been closely delimited. It appears to be remarkably restricted. Rutter (1922) states that elephants are "found only on the east, being confined to the area between the Labuk and Sembakong Rivers," a north-south distance of about 125 miles. There is no reason to doubt this, as elephants have not been reported outside this area. The western limit of its range is unknown; it was abundant (at least seasonally) as far inland as Deramakot in 1956, and was said to be seasonally abundant at Kalabakan. Elephants are certainly absent from the west coast. H. G. Keith, former conservator of Forests, Sandakan, in 1949 estimated the total number of elephants in North Borneo at about 2,000 (verbal communication from G. S. Brown, who succeeded Mr. Keith).

Within this limited area the elephant appears to be quite common. Pryer (1881) stated that "to the south of the Bay of Sandakan vast herds roam the forest." We found them to be common in the Bukit Kretam area, where their footprints and characteristic dung piles were everywhere. We also heard elephants trumpeting on the Segaliud River and in the Sapagaya Forest Reserve area. G. S. Brown told me that herds of 15 to 40 are not uncommon in the Sandakan Bay area.

Few specimens of the Bornean elephant exist in collections, and apparently no measurements have ever been recorded. Our specimen is a fully adult female with the last molar coming into function, as is shown by X-rays. Measurements of this skull, with corresponding measurements of other Asiatic elephant skulls, are:

	<i>N. Borneo</i>	<i>Sumatra</i>	<i>Sumatra</i>	<i>Captive</i>
Sex	♀	?	?	?
Greatest length (ant. border premax.-occip. condyle)	670	725	755	935
Zygomatic breadth	540	620	650	820
Interorbital breadth	295	373	378	498
Breadth across premax. at base of incisors	226	320	305	—
Minimum breadth across premaxillaries	197	248	238	357
Length M_3	230	—	—	—
No. lamellae in M_3	18	—	—	—
Tusk length	130	—	—	—
Tusk diameter	26	—	—	—

An isolated lower third molar, about half of which was in function, was found on the forest floor at Bukit Kretam. The tooth measures 310 mm. in length and is composed of 22 lamellae. Little is known of the habits of the Bornean elephant. It is said to be very destructive of gardens. We made no attempt to hunt these shy animals. I examined a spot on the bank of the Pinang River where elephants had been feeding on nipa (*Nipa fruticans*), apparently the preceding night. Judging from the tracks there had been an adult and a calf in the party. The nipa was trampled over a considerable area, and a considerable quantity had been consumed.

Specimens examined.—Gomantong Forest Reserve (skull only); Bukit Kretam (molar tooth only).

PERISSODACTYLA

Family RHINOCEROTIDAE

Didermocerus sumatrensis Fischer.

Sumatran Rhinoceros.

Rhinoceros sumatrensis Fischer, 1814, *Zoogn.* ed. 3, vol. 3, p. 301.—Sumatra.*Didermocerus sumatrensis* Brookes, 1828, *Cat. Anat. Zool. Mus. of J. Brookes*, London, p. 75.

The smallest of living rhinoceroses, measuring about 4 feet at the shoulder (Hose, 1893). Color dark brown to black, the body thinly covered with long dark hairs, longer on ears and tail. Two horns on the rostrum.

This animal is widely but very thinly distributed throughout Borneo. It is well known in North Borneo, but the only North Bornean specimen I have seen is a mounted head exhibited in the Singapore National Museum and labelled Tingkayu, N. Borneo, 1927; Tingkayu is a river on the east coast, emptying into Darvel Bay.

Banks (1931) wrote of its habits: "It is a browser, feeding on twigs and leaves, knocking down small saplings, making a great noise about its feeding and leaving a broad path of broken trees and trampled undergrowth . . . They are said to be fond of a muddy bath by the river side, and I have seen the tracks where they and many pigs wallowed in the hollows of a mountain ridge."

The horns of this animal are greatly prized by the Chinese for medicinal purposes, and the rhinoceros has been greatly persecuted to supply the market with these. Its numbers appear to have been much reduced during the past hundred years.

Locality records.—Tingkayu (Singapore National Museum).

ARTIODACTYLA

Family SUIDAE

The common Bornean wild pig is *Sus b. barbatus*. The species is represented in Sumatra, the Malay Peninsula, and many of the smaller islands by the closely related *Sus barbatus oi*. A dwarf race, *Sus barbatus ahoenobarbus*, occurs on Balabac, Palawan, and the Calamianes in the Philippines; condylobasal length in adult male 308–327.

A supposed giant pig (*Sus gargantua* Miller, 1906, *Proc. U.S. Nat. Mus.*, 30: 743) was described from southeastern Borneo on the basis of a single skull, and Tucker (*Proc. Zool. Soc. London*, 1931: 487) assigned a second specimen, from the Baram district, to this species. It is very probable that *Sus gargantua* is merely an aberrant form of *Sus barbatus*.

Sus barbatus barbatus Müller.Bearded Pig, *Babi utan*. (Plate 22).

Sus barbatus Müller, 1838, *Tijdschr. Nat. Geschied. Physiol.*, 5: 149.—Banjermassin, South Borneo.

Sus barbatus barbatus Lydekker, 1915, *Cat. Ungulate Mam. Brit. Mus.*, vol. 4, p. 340.

A large pig characterized by a prominent fleshy protuberance, covered with long bristles directed upward and forward, on either side of the snout above and slightly behind the tusk; a conspicuous "beard" of long bristles along the edge of the jowls; and a mane of backwardly-directed bristles extending along the dorsal midline to about the middle of the back. Body thinly haired.

According to Banks (1931) the color varies from "chalky white" through gray to yellowish. An adult male collected by us at Bukit Kretam is reddish above, the mane conspicuously so, dark brown to black below, and black on lower legs and feet; the bristles of the beard are buff at the base, reddish brown at the tip. The scalp of a second male, collected in the Sapagaya Forest Reserve, is much darker; the bristles of the beard are black proximally and bright reddish brown distally. An adult female from near Sandakan is even blacker. According to Banks sucklings are dark brown with three pale longitudinal stripes on the flanks and traces of a fourth and fifth "near the elbow joint." Pfeffer (1959) says that the young are usually not striped.

Measurements of an adult male from Bukit Kretam are: head and body 1,365, tail 225, hind foot 280, ear 85, shoulder height 890. An adult female from near Sandakan measured: head and body 1,220, tail 230, hind foot 290, shoulder height 890. Pfeffer gives the measurements of an adult male "of average size" as: head and body 1,760, tail 230; adult female, head and body 1,500, tail 280.

Mean and extreme measurements of four adult male skulls from Bukit Kretam and the Sandakan Bay area are: greatest length 420 (410–425), condylobasal length 389 (379–397), zygomatic breadth 156 (147–168), palatal length 296 (287–302), maxillary tooththrow 129.8 (128–131), M^3 37.3 (36–38) in length, 21.6 (20.5–23.5) in breadth. Skull measurements of an adult female from Kalabakan are: greatest length 367, condylobasal length 347, zygomatic breadth 126, palatal length 265, maxillary tooththrow 122.5, M^3 36 in length, 20 in breadth. Where comparable, these measurements are very similar to those given by Lyon (1911) for pigs from the coastal area and adjacent islands just south of Pontianak in Indonesian Borneo. Lyon's figures for the maxillary tooththrow in 13 adult males are 130.3 (120–146).

The bearded pig appears to be abundant in all parts of Borneo, and is often a nuisance. Places where they had been rooting were a common sight in the forest at Bukit Kretam. They range up to an elevation of 7,000 feet on Mt. Murud. They are essentially crepuscular and nocturnal, but are sometimes active during the day, especially if it is raining. During the heat of the day an individual usually rests on a bed of twigs and branches that it has cut with its teeth and arranged into a litter. Bearded pigs swim rivers readily, and Abbott (in Lyon, 1911) even reported droves of pigs attempting to swim across Klumpang Bay. Various observers (e.g., Pfeffer, 1959) have reported massive regular migrations of these animals. According to Banks their feeding consists of "rooting in the ground, tearing open rotten logs, picking up fruit, gnawing roots, and consuming any carrion handy." Their greatest enemies are crocodiles.

According to Abbott the numbers of fetuses found in five pregnant females were 4, 7, 9, 10, and 11, respectively.

Specimens examined.—Total 8. Bukit Kretam, 1 skin and skull, 1 skull only; Sandakan mi. 8, 1 skin and skull; Sapagaya Forest Reserve, 1 skull and scalp; Goman-tong Forest Reserve, 1 skull only; Deramakot, 1 skull only; Kalabakan, 2 skulls only.

Family TRAGULIDAE

Two species of mouse deer occur in Borneo. Both are represented by very slightly differentiated Bornean races of widely distributed species. The smaller *Tragulus javanicus* ranges over the whole Malaysian Subregion and north into Indochina and Siam,

while the larger *T. napu* is restricted to the Malaysian Subregion. The numerous described races are based almost entirely on color and pattern differences. Neither species occurs in the Philippines; the genus *Tragulus* is represented there only on Balabac Island.

***Tragulus javanicus klossi* Chasen.**

Small Mouse Deer, *Pelandok*. (Plate 23).

Tragulus kanchil klossi Chasen, 1934, Bull. Raffles Mus. 9: 98.—Bettotan, near Sandakan, North Borneo.

A small mouse deer with very slender legs. Color above dark brown washed with reddish; individual hairs gray at base, followed by a band of reddish buff, and tipped with dark brown. Flanks without the reddish wash, grizzled buff and dark brown. Belly white with a poorly-defined central area of buff; a narrow brown stripe from throat to about the middle of the belly. Legs bright reddish brown. A narrow black nuchal stripe from occiput to shoulders. Gular chevron marking dark brown. The young are unspotted.

Measurements.—Mean and extreme measurements of four adults of both sexes from the Sapagaya Forest Reserve and Bukit Kretam are: head and body 469 (455–483), tail 81 (70–93), hind foot 137.5 (135–140). Eleven adult skulls from the same region measure: greatest length 98.8 (97–100.4), condylobasal length $91.8 \pm .4$ (90.0–94.0), zygomatic breadth 44.1 (42.5–46), palatal length 60.6 (59.0–63.0), upper cheek teeth $34.45 \pm .36$ (33.0–37.2), upper canine of 11 males 15.2 (12–17.5), of 6 females 4.8 (4.0–6). Except for canine length there is no statistically significant sexual dimorphism in these measurements. Mean and extreme weights of 4 adult males were 2,220 (2,000–2,500) grams, of 3 non-pregnant adult females 2,320 (2,200–2,500) grams.

No comparable data are available for *T. j. hosei* of Sarawak. Measurements of a series of 10 specimens from the Kendawangan River in northwestern Indonesian Borneo, identified by Lyon (1911: 68) as *T. j. longipes*, run slightly smaller than *T. j. klossi*, as shown in the following table.

Comparative Mean Measurements of *Tragulus javanicus*

		<i>T. j. klossi</i>	<i>T. j. longipes</i> (data from Lyon)
No. of specimens	...	11	10
Hind foot	...	137.5	130.4
Condylobasal length	...	91.8	87.1
Upper cheek teeth	...	34.5	31.9

The small mouse deer is one of the commonest mammals in both primary and secondary forest. We found it active both day and night. We usually observed them as isolated individuals, although they were occasionally seen in pairs, or as a female accompanied by a partly-grown young.

The posture of this animal is not at all deer-like. It stands with the back arched and the rump curved downward. Locomotion is surprisingly suggestive of a rabbit. A startled animal moves off in a bouncing stiff-legged gallop that superficially resembles the saltation of a rabbit. After running a short distance the animal stops. Despite their small size and delicate appearance the flesh of these animals is coarse, far inferior to that of the muntjac or sambhur deer.

Of 14 females collected between 24 April and 8 August 6 were pregnant. Dates of pregnancy were May 9, June 5, July 26 (3), and August 8. Each doe carried a single young.

Specimens examined.—Total 30. Sandakan mi. 8 (5), Sapagaya Forest Reserve (5), Bukit Kretam (3), Deramakot (10), Kalabakan (7). Chasen and Kloss record it from Samawang and Bettotan, and Lyon (1911) from the Kinabatangan River.

***Tragulus napu borneanus* Miller.**

Large Mouse Deer.

Tragulus borneanus Miller, 1902, Proc. Biol. Soc. Wash., 15: 174.—North Borneo, Suanlamba River (flowing into south end of Sandakan Bay).

Tragulus javanicus borneanus Kloss, 1918, Jour. Fed. Malay States Mus., 7: 248.

Somewhat larger than *Tragulus javanicus* and with much heavier legs. Color above dark brown washed with buffy-red along the back; individual hairs on the back are gray at the base, followed by a band of buffy red, and tipped with dark brown. Flanks paler than back, the buffy gray under color showing through to produce a mottled effect. Belly white fore and aft, with a central area lightly washed with brown. Legs reddish brown. The dark nuchal stripe seen in *T. javanicus* is typically absent, although two individuals in our series have a poorly-defined dark line running back from the occiput. Gular chevron marking dark brown, coarsely flecked with red. There is much individual variation in the intensity of coloration.

Measurements.—Mean and extreme measurements of eight adults of both sexes from eastern North Borneo are: head and body 529 (527–557), tail 87 (78–105), hind foot 151 (142–165). Seven adult skulls measure: greatest length 110.4 (104.8–120), condylobasal length 104.8 (99.8–114), zygomatic breadth 50.1 (48.3–53.3), palatal length 70.5 (66–77), upper cheek teeth 37.9 (36.5–39.4). Two adult males weighed 3,625 and 4,000 grams, a non-pregnant female 3,500 grams.

As is true of *T. javanicus*, specimens of *T. napu* from eastern North Borneo are slightly larger than specimens from Indonesian Borneo, based on Lyon's measurements of the latter.

Little is known of the habits of this mouse deer. It appears to be less common than the smaller *T. javanicus*. It has been taken at an altitude of 3,700 feet in the Kelabit country of Northern Sarawak.

Of 4 females collected between 5 June and 2 August, 3 were pregnant. These were collected June 15, July 17, and August 2, and each contained a single young.

Specimens examined.—Total 8. Sandakan mi. 8 (2), Sapagaya Forest Reserve (3), Kalabakan (3). Chasen and Kloss record it from Bettotan and Rayoh, and Lyon from the Suanlamba and Kinabatangan Rivers.

Family CERVIDAE

***Muntiacus muntjak pleiharicus* Kohlbrugge.**

Barking Deer, *Kijang*. (Plate 22).

Cervulus pleiharicus Kohlbrugge, 1895, Natuurk. Tijdschr. Neth.-Indies, 55 (2): 192.—Pleihari, Southeast Borneo.

Muntiacus rubidus Lyon, 1911, Proc. U.S. Nat. Mus., 40: 73.—Pamukang Bay, southeastern Borneo.

General color reddish buff, darker along the midline where an admixture of brown forms an indistinct dorsal line, darkest and most clearly marked on the neck. Top of head brown, face buffy brown, chin and throat whitish. Under surface pale reddish

buff, becoming lighter on the abdomen. Axillary and inguinal regions whitish, the light color extending halfway or more down the inner sides of legs. Outer sides of legs colored like sides of body. Tail white (buff in one individual), with a narrow dorsal stripe of dark brown. There is some color variation in our series, mostly in the intensity of the brown along the dorsal midline and in the amount of red in the pelage.

The fawn has "two rows of sometimes almost continuous white spots down the back and two or more irregular rows on each flank" (Banks, 1931).

Antlers.—The antlers apparently vary greatly with age. In old males (*rubidus* of authors) the pedicel is heavy, there is a prominent burr, the antlers curve sharply inward at the tip, and there is a short basal spine. No measurements of fully developed antlers are available. The antlers vary greatly in form, and exhibit many individual anomalies. In younger but fully adult males (*pleiharicus* of authors) the pedicel is more slender, there is little or no burr, and the antlers are short simple spikes. 50–75 mm. long. All three of our males have antlers of the *pleiharicus* type, although all are fully adult.

Measurements.—Three adult males measure: head and body 860, 905, 894; tail 200, 135, 142; hind foot 288, 275, 256; skull, greatest length 192, 185, 176; condylo-basal length 174, 175, 169; palatal length —, 111, 107; zygomatic breadth 84, 82, 79; maxillary tooththrow 57, 57, 49; canine length 20, 21, 18.5. Weights of these three animals were 17.7, 15, and 13.5 kilograms. Three adult females measure: head and body 920, 897, 908; tail 150, 153, 155; hind foot 275, 282, 260. Skull, greatest length 185, 191, 171; condylobasal length 171, 183, 164; palatal length 113, 119, 105; zygomatic breadth 79, 77.5, 75; maxillary tooththrow 56.5, 54.2, 51.5. Weights of two non-pregnant females were 15.6 and 14.5 kilograms.

The seven animals collected by us were in pairs, except for one female in an advanced stage of pregnancy. This bears out Banks' statement that "it is usual to find them in pairs." All were in primary forest, and one pair was shot in late afternoon, another in mid-morning. The "barking" of this species was heard during daylight hours in both primary and old logged forest.

According to Banks the antlers are shed in May and renewed in August, "though it is doubtful if the shedding is annual." Our three males, collected June 8, June 11, and July 28, all had well developed antlers. Females collected on June 11 and June 26 were pregnant; each contained a single young.

Specimens examined.—Total 7. Bukit Kretam (2), Sapagaya Forest Reserve (2), Kalabakan (3). Chasen and Kloss record this species from Rayoh.

***Cervus unicolor brookei* Hose.**

Sambar Deer, *Rusa*.

Cervus brookei Hose, 1893, Ann. Mag. Nat. Hist. (6) 12: 206.—Mt. Dulit, Sarawak.

Cervus unicolor brookei Gyldenstolpe, 1920, K. Svenska Vet. Akad. Handl., 60, no. 6, p. 50.

A young male from Bukit Kretam may be described as follows. General color gray-brown, washed with rufous on the nape, back, and hind quarters; the red is brightest on the buttocks. Individual hairs gray at the base, followed by a broad band of brown, a narrower band of buff or hazel, and tipped with black. A narrow black stripe begins in front of the shoulders and extends along the dorsal midline onto the tail. Tail black above and below. Underside brown, becoming cream on posterior belly. Legs cream on inner surface to wrist and ankle, below wrist and ankle buffy cream with a narrow brown line on anterior surface.

Antlers.—The antlers of *brookei* are distinctly shorter than those of *equinus* from the Malay Peninsula (Lyon 1907: 585). There are the three tines typical of this species: a brow tine coming off the main beam at an acute angle, and a single terminal forking of the main beam. The inner tine of the terminal fork is smaller than the outer, which appears to be a direct continuation of the beam.

Measurements of the right antler of an individual taken 8 miles north of Sandakan are: length along outside curve 478 mm., burr to tip of brow tine along convexity 186, circumference above burr 133, circumference above brow tine 115. The largest antler measured by Lyon (1911: 70) was from Pulo Laut; the right antler measured 562 mm. along the outside curve.

Measurements.—The upper cheek teeth of the above male from near Sandakan measure 100 mm.

Sambar appeared to be common in the Sandakan Bay and Dewhurst Bay areas. They are nocturnal and therefore rarely seen. According to Hose this species "feeds on grass, especially the green grass near water, and various wild fruits, of which it is very fond, but it also browses greatly on shoots and leaves of trees."

Specimens examined.—Bukit Kretam (1), Sandakan mi. 8 (1 skull and antlers only).

Family BOVIDAE

Bos javanicus lowi Lydekker.

Temadau.

Bos sondaicus lowi Lydekker, 1912, Proc. Zool. Soc. London, 1912: 902.—Sarawak.

Bibos javanicus Hooijer, 1956, Zool. Meded. Rijksmus. Leiden, 34: 223.

We did not collect this species, and I have had no opportunity to examine specimens. There appear to be no North Bornean records of the temedau, although it is well known to the inhabitants and unquestionably occurs in the colony.

The descriptions given by Lyon (1911) and Banks (1931) of specimens from south-eastern Dutch Borneo and Sarawak, respectively, may be summarized as follows. General color of male glossy black; cheeks, axillary and inguinal regions, and a small area at base of tail chocolate brown; feet dirty white to above wrist and ankle; belly dirty white; a white patch on hind quarters; tail brown at base, becoming black toward the tip. General color of female reddish brown above, becoming paler posteriorly, dark brown below; a narrow black stripe along the dorsal midline from shoulder to base of tail; stockings and buttock patch dirty white; tail the color of body proximally, the terminal third black.

According to Lydekker the Bornean race of *B. sondaicus* is distinguished from the Javan race by its stouter, less curved, and more upright horns.

Lyon gives the following measurements of an adult female from Pamukang Bay, southeastern Borneo: head and body 2060, tail 670, hind foot 560, height at shoulder 1280; skull, condylobasal length 405, zygomatic breadth 175, maxillary toothrow 128. Weight of cut-up carcass, without entrails, 176 kilos (386 pounds).

Dried manure of the temadau was present in the camp clearing in the Sapagaya Forest Reserve when we arrived, but the animals were gone. The area had been occupied by Forestry Department personnel for a month before our arrival.

According to Banks the temadau is partial to secondary growth rather than primary forest. The same author says they travel in herds of 8 or 10 individuals.

Locality records.—None.

LOCALITIES IN NORTH BORNEO AT WHICH MAMMALS HAVE BEEN COLLECTED¹⁸

<i>Locality.</i>	<i>District.</i>	<i>Co-ordinates.</i>	<i>Collector.</i>
Abai	Sandakan	5° 42' N, 118° 23' E	Schultz & Washburn 1937.
Balembangan Island		7° 16' N, 116° 53' E	Chasen & Kloss 1927.
Bangi Island		7° 15' N, 117° 10' E	Chasen & Kloss 1927.
Baturong Caves	Lahad Datu	5° 02' N, 118° 20' E*	P. Orolfo 1930.
Benoni	Jesselton	6° N, 116° 05' E*	
Berhala Island	Sandakan	5° 52' N, 118° 09' E	P. Orolfo 1930.
Bettotan	Sandakan	5° 48' N, 117° 50' E	Chasen & Kloss 1927.
Bongon	Kudat	6° 33' N, 116° 50' E	A. H. Everett 1893.
Bukit Kretam	Kinabatangan	5° 30' N, 118° 33' E	D. D. Davis 1950.
Bundu Tuhan	Jesselton	5° 58' N, 116° 32' E	J. A. Griswold 1937.
Deramakot	Kinabatangan	5° 17' N, 117° 33' E	R. F. Inger 1956.
Dewhurst Bay	Kinabatangan	5° 39' N, 118° 37' E	D. D. Davis 1950.
Gomantong Caves	Kinabatangan	5° 33' N, 118° 04' E	F. N. Chasen 1929.
Jesselton	Jesselton	5° 59' N, 116° 05' E	J. A. Griswold 1937.
Kalabakan	Tawau	4° 25' N, 117° 29' E	H. G. Deignan 1937. R. F. Inger 1956.
Kinabalu, Mt.	Jesselton	6° 05' N, 116° 33' E	A. H. Everett 1892. J. Whitehead 1887-8. J. A. Griswold 1937.
Kinabatangan River	Kinabatangan	5° 39' N, 118° 37' E	R. F. Inger 1956.
Kretam Besar River	Kinabatangan	5° 32' N, 118° 32' E	D. D. Davis 1950.
Kretam Kechil River	Kinabatangan	5° 31' N, 118° 33' E	D. D. Davis 1950.
Kuamut	Kinabatangan	5° 14' N, 117° 30' E	R. F. Inger 1956.
Kudat	Kudat	6° 53' N, 116° 51' E	Chasen & Kloss 1927.
Labuan Island		5° 20' N, 115° 15' E	J. Motley, pre-1855. A. H. Everett 1892.
Lahad Datu	Lahad Datu	5° 02' N, 118° 20' E	
Lambidan	Beaufort	5° 23' N, 115° 22' E	
Lumu Lumu	Jesselton	6° 02' N, 116° 34' E*	J. A. Griswold 1937.
Madai Caves	Lahad Datu	5° 02' N, 118° 20' E*	P. Orolfo.
Malawali Island		7° 04' N, 117° 17' E	Chasen & Kloss 1927.

¹⁸. Boundaries as shown on U.S. Army Map Service, Borneo series, T532, dated 1945. District boundaries have changed slightly since 1945. Co-ordinates marked with an asterisk (*) are approximate.

<i>Locality.</i>	<i>District.</i>	<i>Co-ordinates.</i>	<i>Collector.</i>
Mengalong River	Beaufort	5° 02' N, 115° 27' E	
Merutai Besar River	Lahad Datu	4° 26' N, 117° 46' E	H. G. Deignan 1937.
Mumiang	Sandakan	5° 49' N, 118° 20' E	D. D. Davis 1950.
Paitan River		6° 32' N, 117° 27' E	A. H. Everett 1892.
Rayoh	Beaufort	5° 15' N, 115° 50' E*	Chasen & Kloss 1928.
Samawang River	Sandakan	5° 54' N, 117° 46' E	Chasen & Kloss 1927.
Sandakan	Sandakan	5° 50' N, 118° 05' E	W. B. Pryer 1881. F. C. Wonder 1929. D. D. Davis 1950.
Sapagaya Forest Reserve	Sandakan	5° 37' N, 118° 04' E	D. D. Davis 1950.
Sapagaya River	Sandakan	5° 37' N, 118° 04' E	
Segaliud River	Sandakan	5° 45' N, 117° 50' E	D. D. Davis 1950.
Semporna	Lahad Datu	4° 29' N, 118° 37' E	J. A. Tubb 1948.
Sepilok Forest Reserve	Sandakan	5° 48' N, 117° 56' E	D. D. Davis 1950. R. F. Inger 1956.
Sipitang	Beaufort	5° 05' N, 115° 33' E	A. H. Everett 1892.
Suanlamba River	Sandakan	5° 40' N, 118° 07' E	
Sungei Tibas	Tawau	4° 26' N, 117° 29' E	R. F. Inger 1956.
Tapadong Caves	Lahad Datu	5° 02' N, 118° 20' E*	P. Orolfo.
Tingkayu River	Lahad Datu	4° 50' N, 118° 10' E	
Tuaran	Jesselton	6° 12' N, 116° 14' E	J. A. Griswold 1937.
Weston	Beaufort	5° 13' N, 115° 36' E	

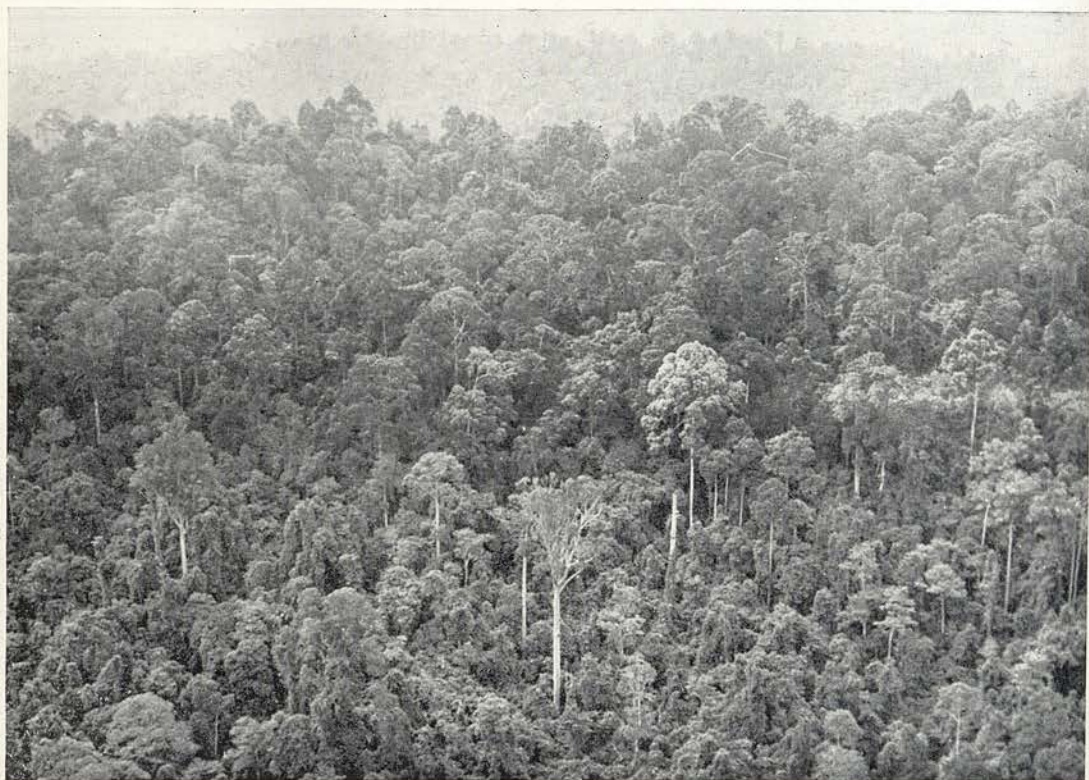
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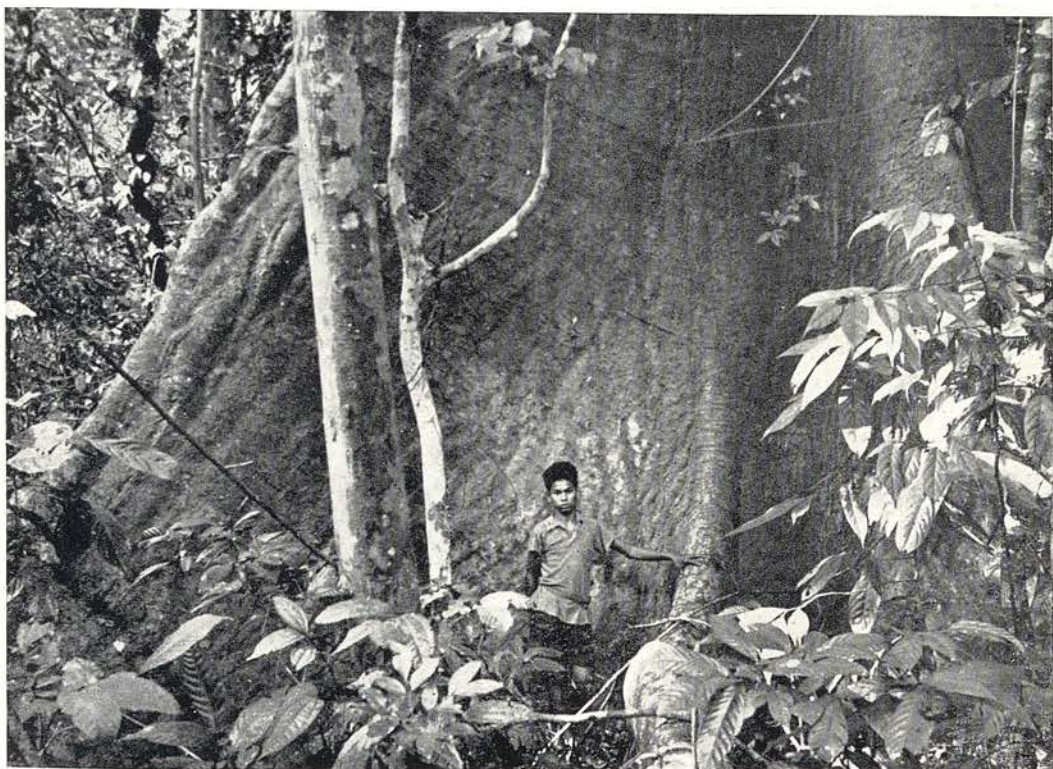
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Above: Aerial view of Tuaran River basin northeast of Jesselton, showing effects of the shifting agriculture characteristic of western North Borneo. July, 1956. *Below:* Kinabatangan River at Deramakot. Old logged forest in near distance, with primary forest rising behind it. May, 1956.



Primary dipterocarp rain-forest at Bukit Kretam, North Borneo. *Above:* Junction between rain-forest (foreground) and nipa-mangrove association (rear). Kretam Kechil River flowing through nipa-mangrove association, with head of Dewhurst Bay at upper right. *Below:* Primary dipterocarp rain-forest on well-drained ridge at Bukit Kretam. The large trees forming the canopy are 150 feet or more in height. 7 September, 1950.



Interior of primary dipterocarp rain-forest on well-drained ridge at Bukit Kretam. *Above:* Mature strangling fig (*Ficus* sp.), one of the giant trees that form the forest canopy, surrounded by smaller trees of the middle and lower stories. Note the woody lianas at the left and in front of the fig tree. *Below:* Base of large mengaris (*Koompassia excelsa*), the largest tree of the North Bornean rain-forest, reaching a height of 275 feet. 30 June, 1950.



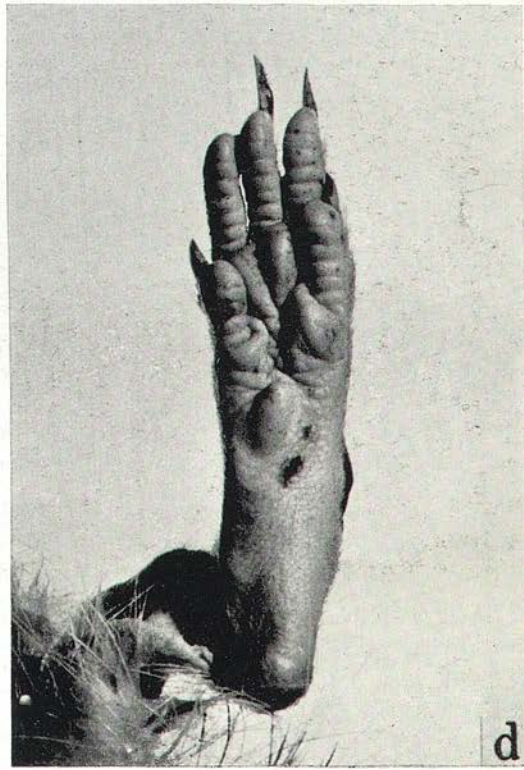
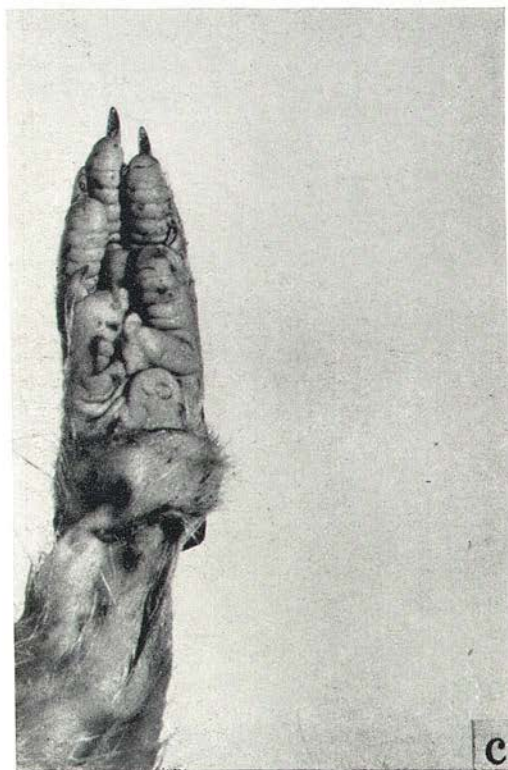
Interior of old logged dipterocarp rain-forest in poorly-drained lowland at Bukit Kretam. The large trees that formed the canopy have been removed, leaving only the smaller trees of the middle and lower stories, 30 June, 1950.



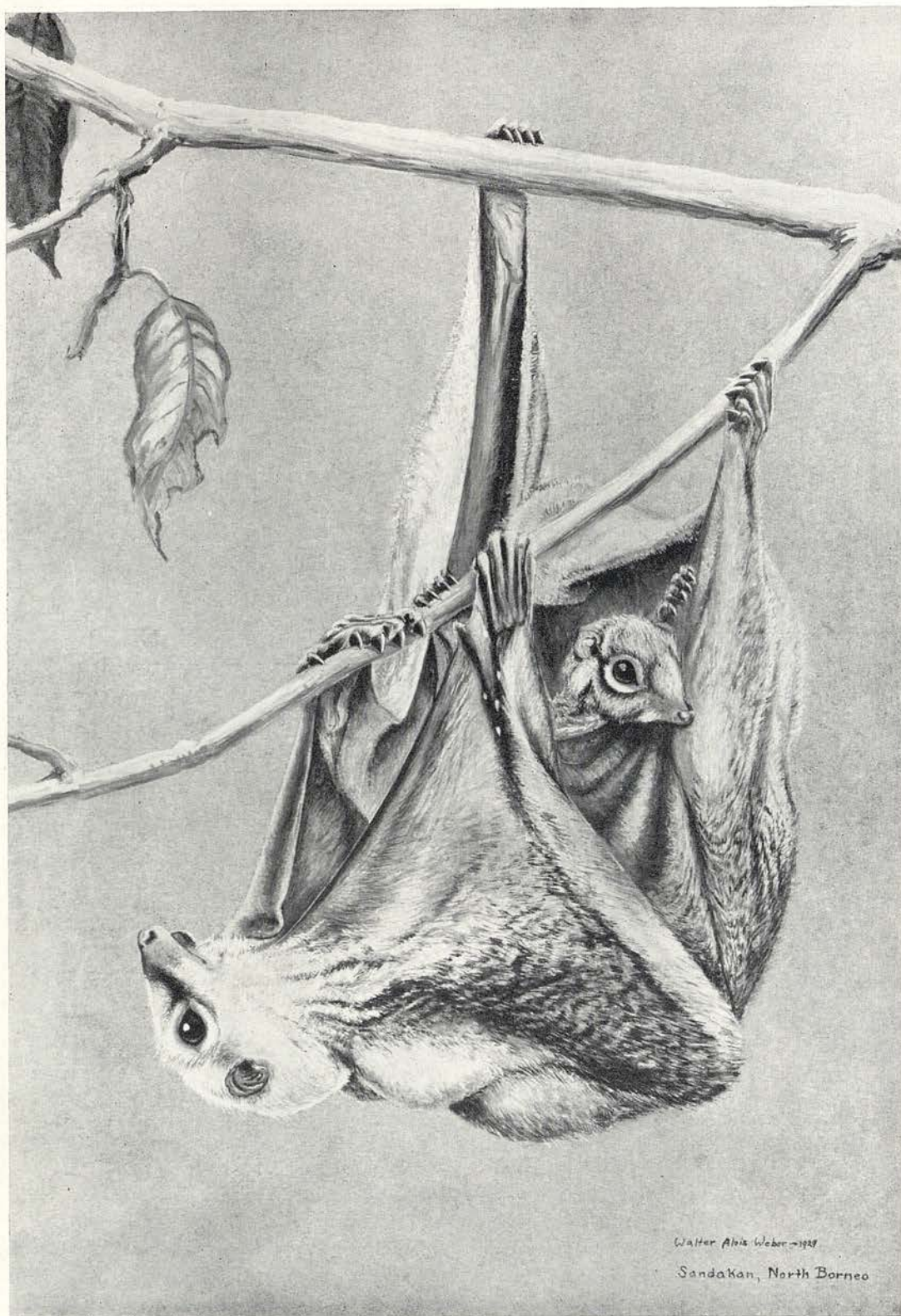
The nipa-mangrove association. *Above*: Lower Pinang River, near Bukit Kretam. 7 September 1950. *Below*: Interior of nipa forest (*Nipa fruticans*) along lower Pinang River. 1 June 1950.



Gymnure (*Echinosorex gymnura albus*). Bukit Kretam, 12 June 1950.



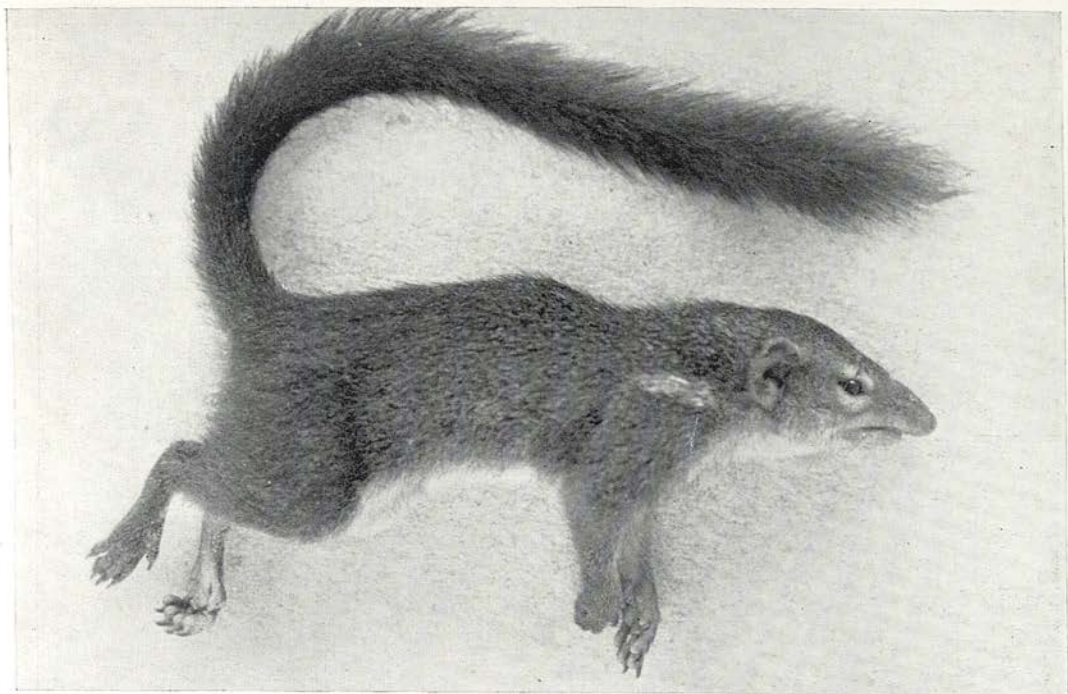
Gymnure (*Echinosorex gymnurus albus*). *a*, dorsal and *b*, ventral views of snout region; *c*, left fore foot; *d*, left hind foot. From a skin preserved in formalin. Sapagaya Forest Reserve.



Walter Alois Weber - 1929

Sandakan, North Borneo

Flying lemur (*Galeopithecus variegatus natunae*), adult female and young. From a painting by Walter A. Weber made at Sandakan in 1929.



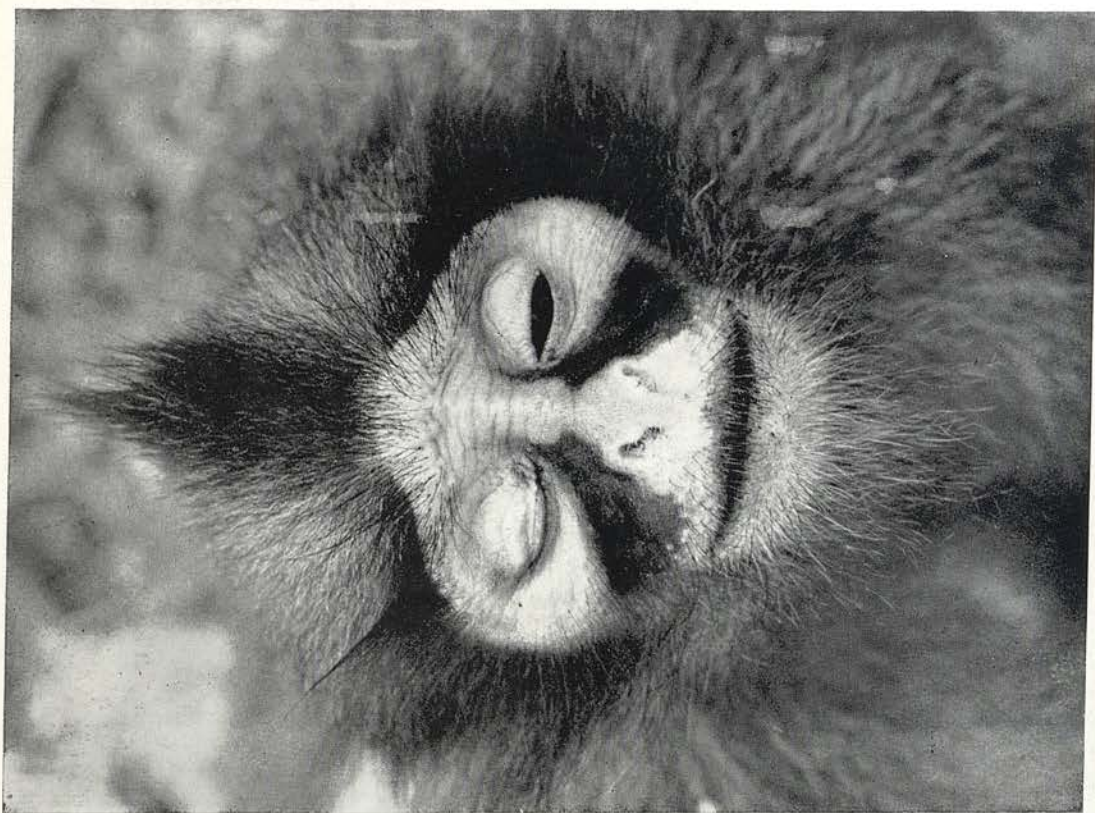
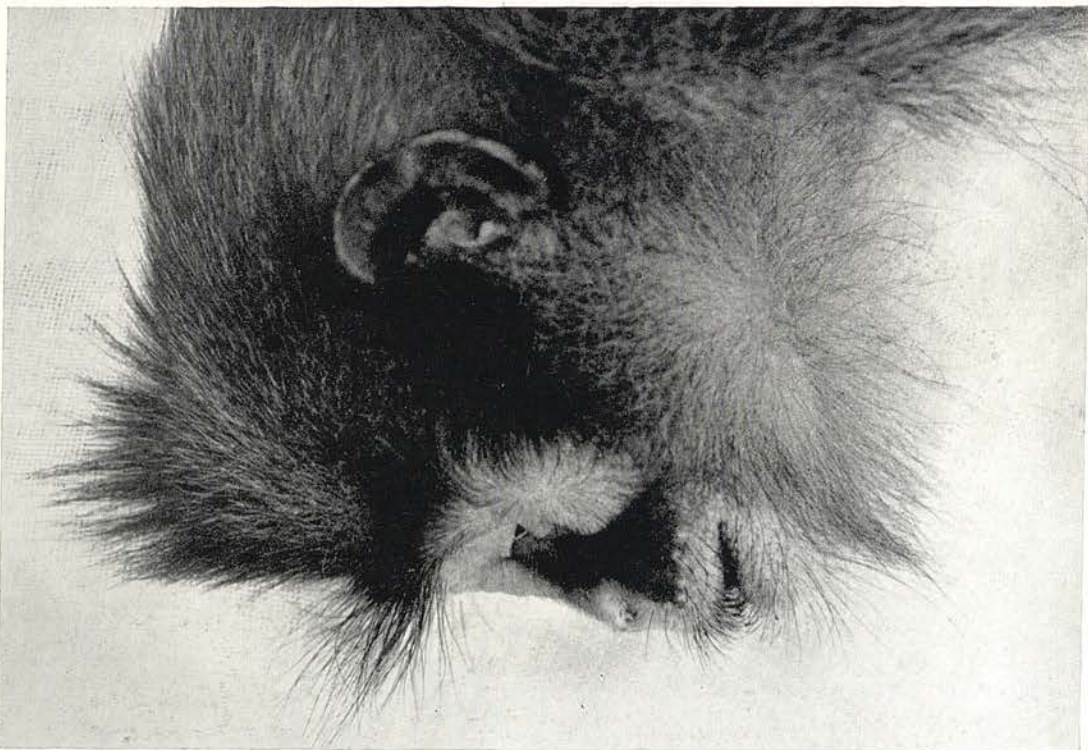
Above: Pigmy treeshrew (*Tupaia minor caedis*), adult male. Sapagaya Forest Reserve, 27 July 1950. Below: Terrestrial treeshrew (*Tupaia tana paitana*), adult male. Sapagaya Forest Reserve, 17 July 1950.



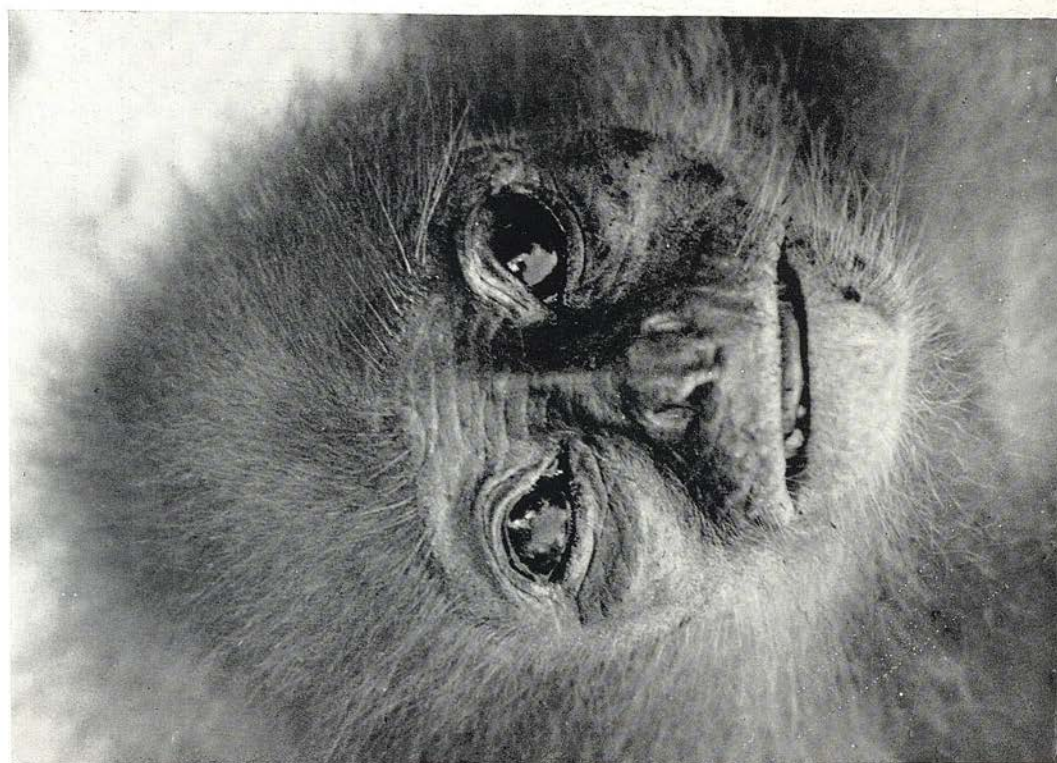
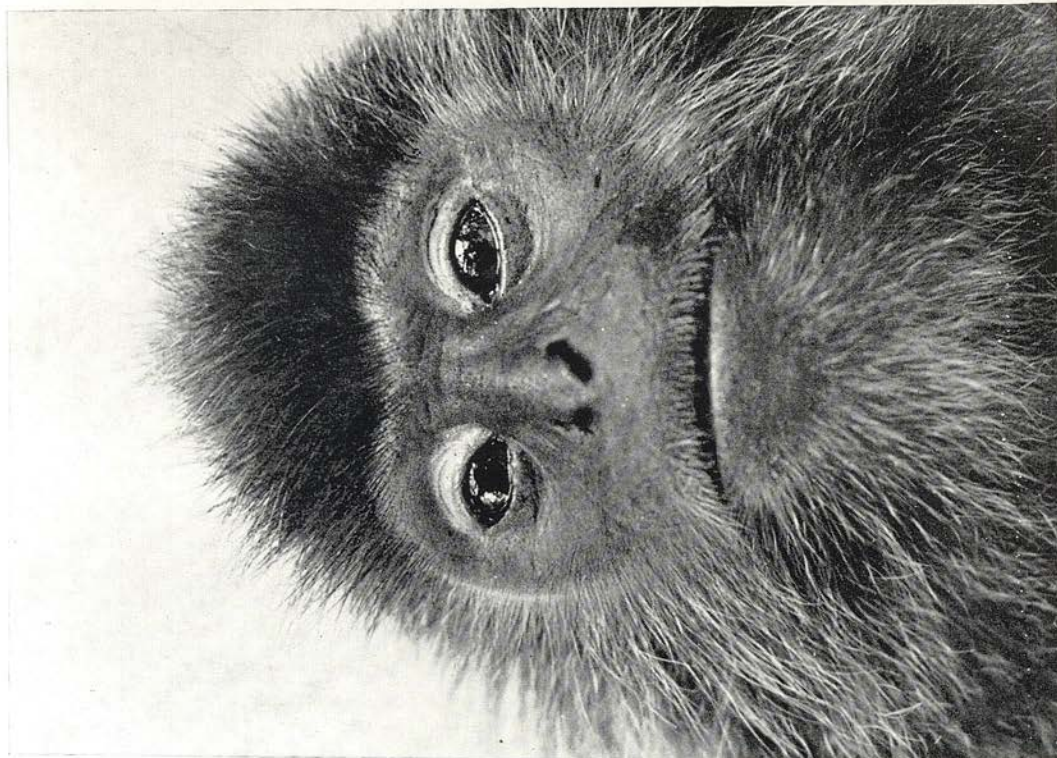
Slow loris (*Nycticebus coucang borneanus*). Sandakan, 1950. Photos by Alan Tubb.



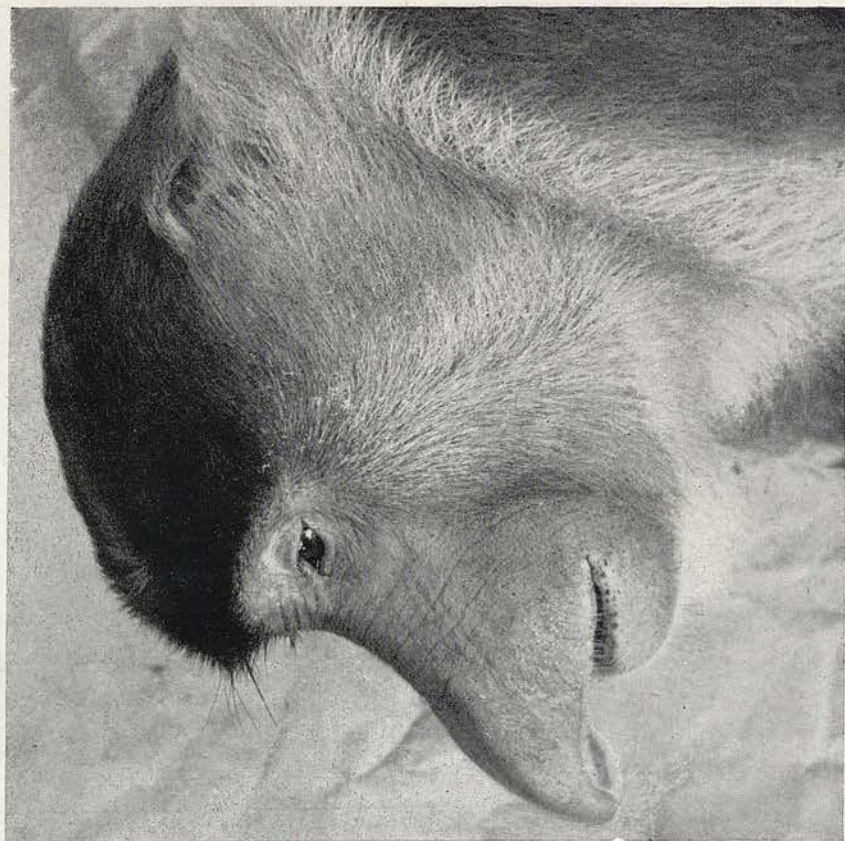
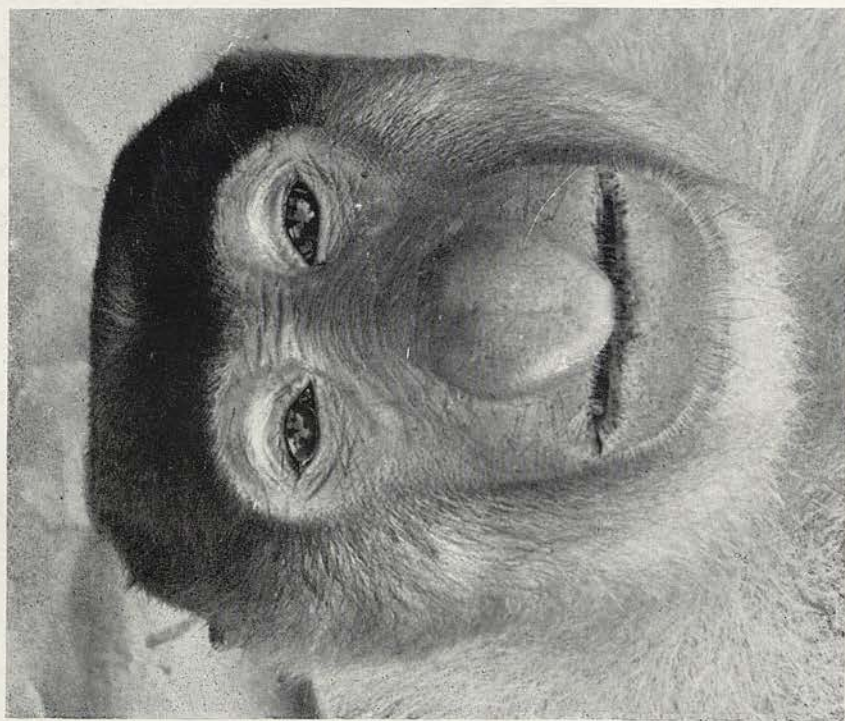
Tarsier (*Tarsius bancanus borneanus*). Bukit Kretam, 5 June 1950.



Gray leaf monkey (*Presbytis hosei sabanus*), adult male. Bukit Kretam, 21 June 1950.



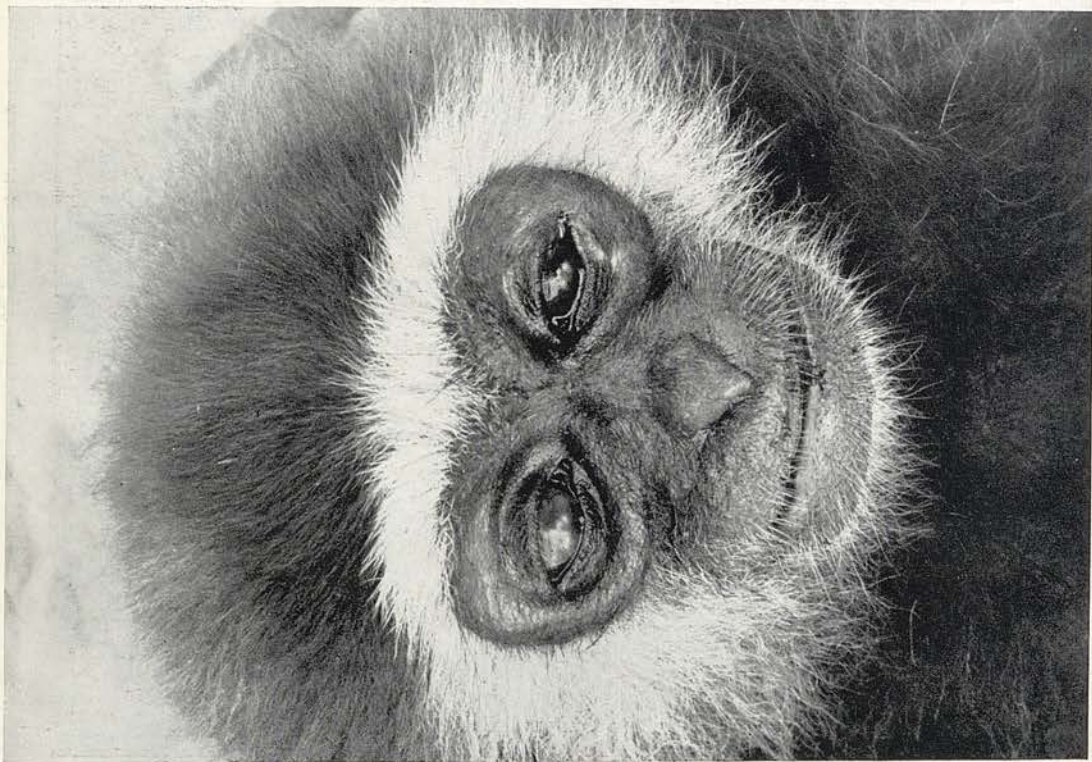
Left: Maroon leaf monkey (*Presbytis rubicundus chrysetus*), adult male, Bukit Kretam, 17 May 1950. Right: Silvered leaf monkey (*Presbytis cristatus ultimus*), adult male, Sapagaya Forest Reserve, 29 July 1950.



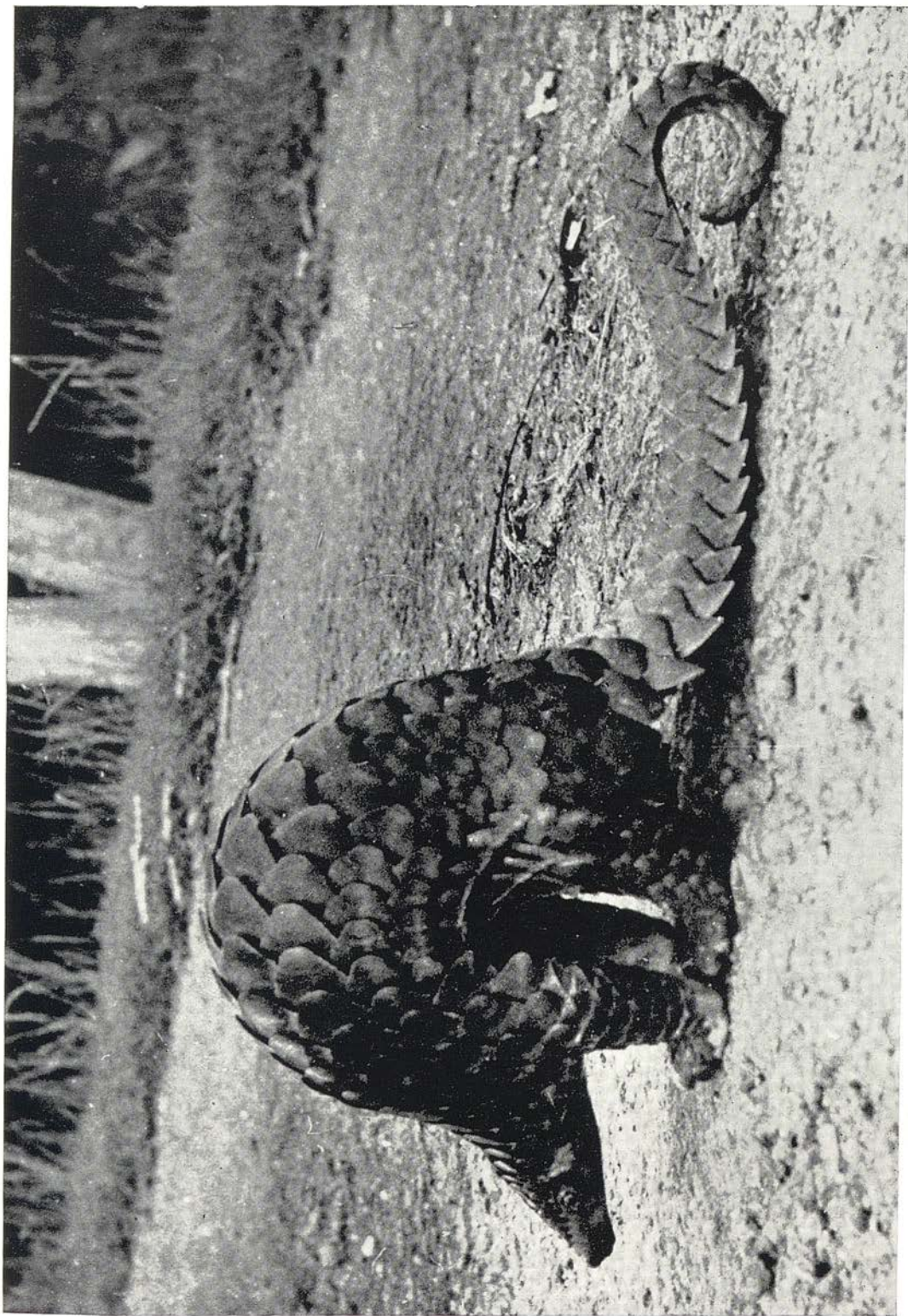
Proboscis monkey (*Nasalis larvatus*), adult male. Trusan Kinabatangan, 28 May 1950.



Right manus and pes of proboscis monkey (*Nasalis larvatus*), adult male, Trusan Kinabatangan, 28 May 1950.



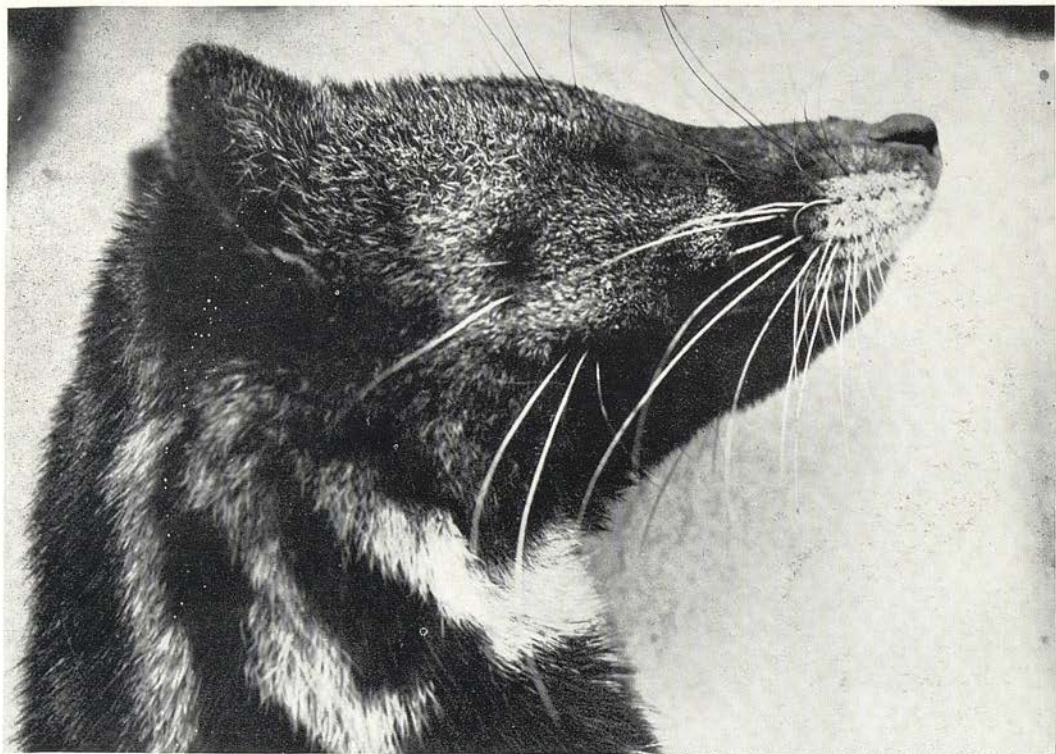
North Bornean gibbon (*Hylobates maloch funereus*), adult male. Right manus and pes. Bukit Kretam, 28 May 1950.



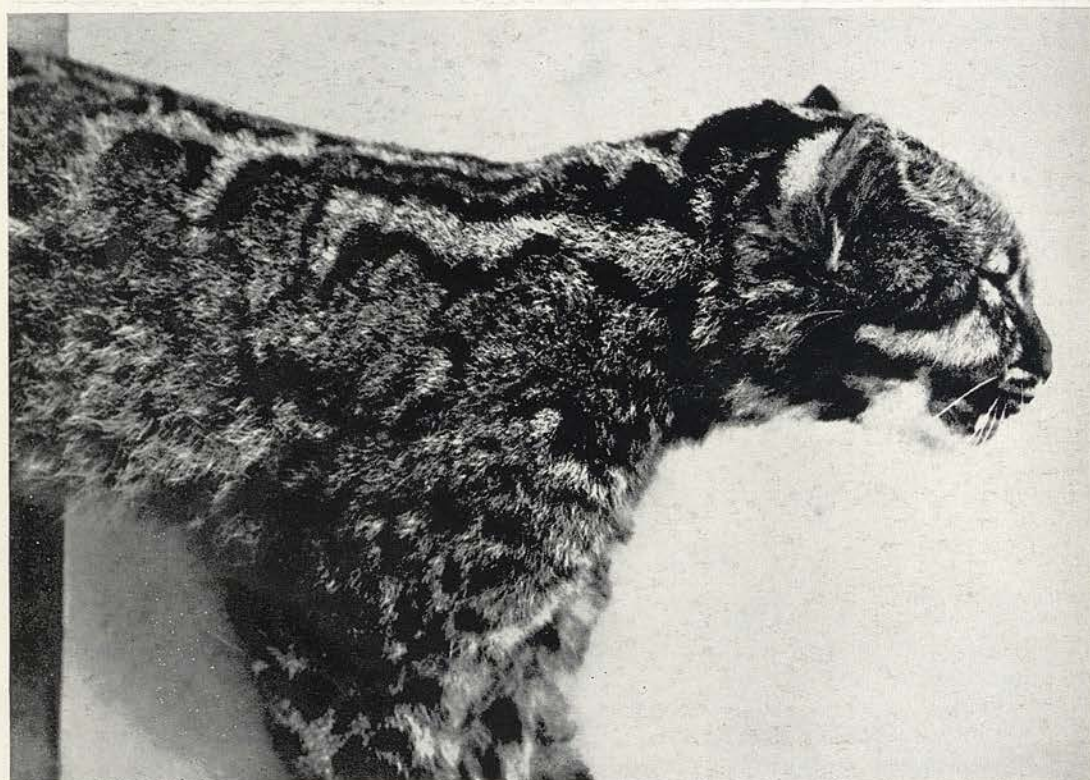
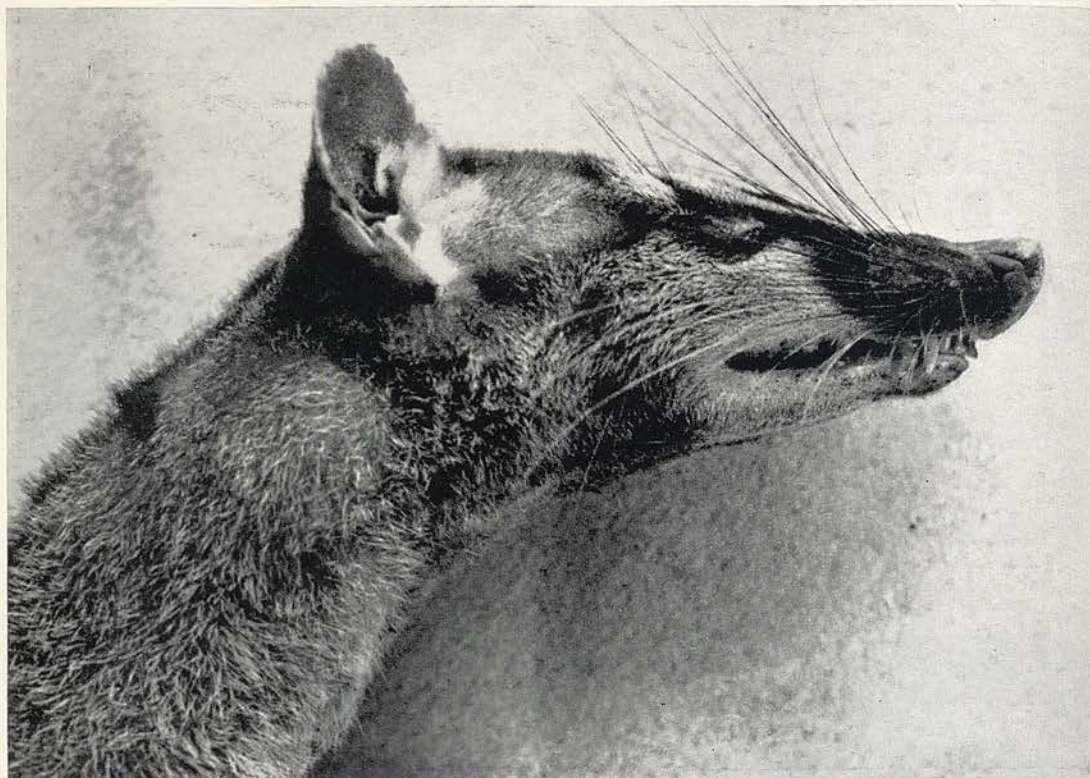
Malaysian scaly anteater (*Manis javanica*). Sandakan, July, 1950.



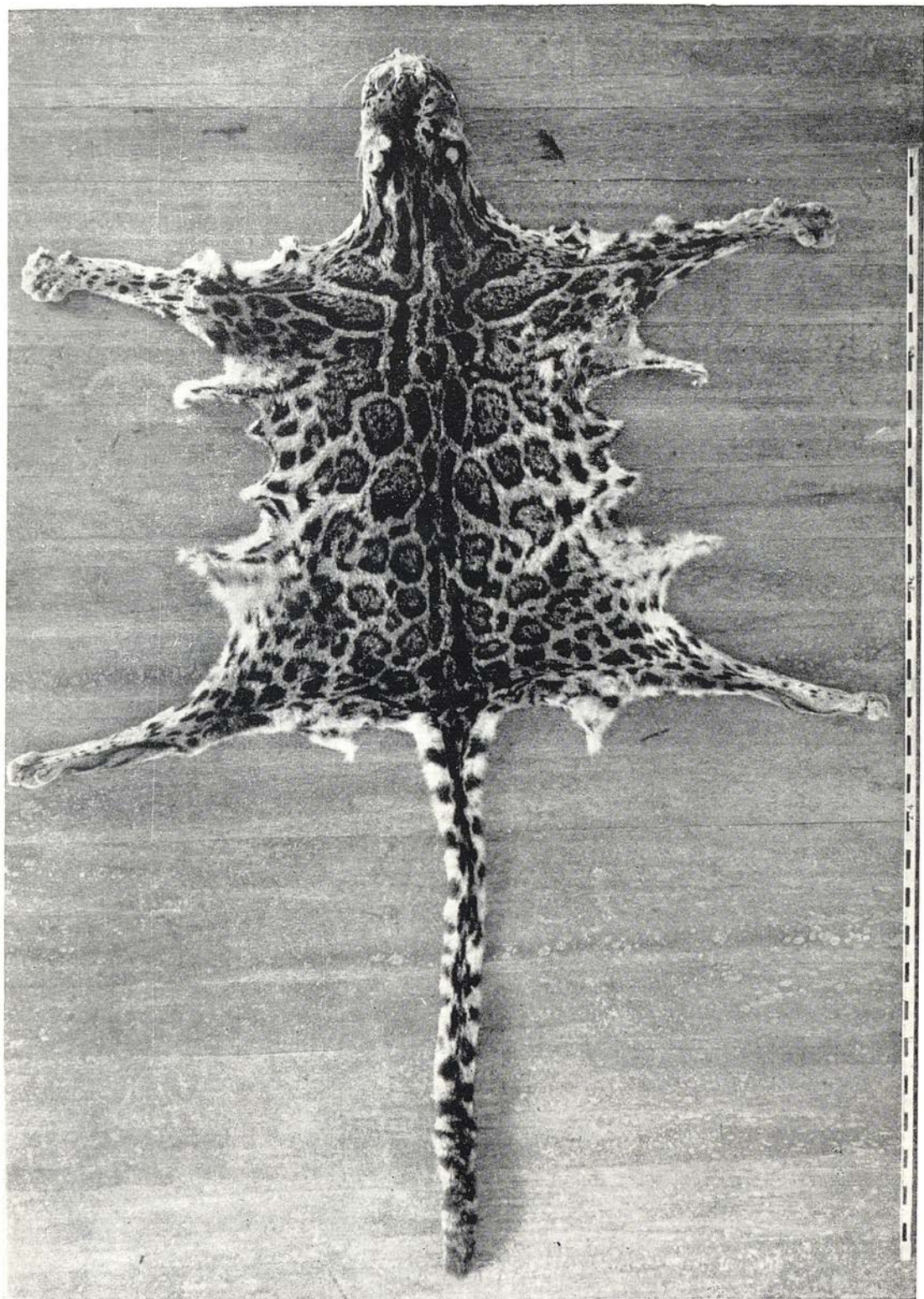
Above: Yellow-throated marten (*Martes flavigula saba*), adult female. Bukit Kretam, 26 June 1950. Below: Teledu (*Mydaus javanensis lucifer*), adult female. Sapagaya Forest Reserve, 30 July 1950.



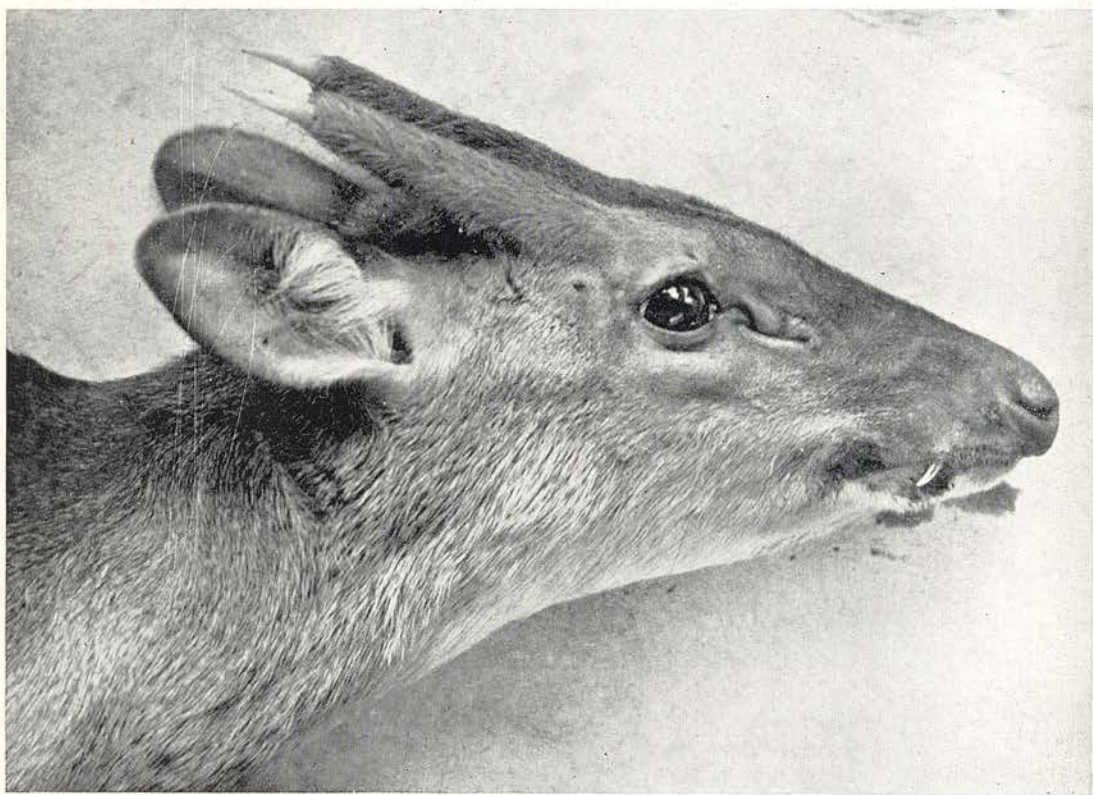
Above: Malayan civet (*Viverra zibetha zibetha*), adult male. Sapagaya Forest Reserve, 20 July 1950. Below: Palm civet (*Paradoxurus hermaphroditus philippinensis*), adult male. Bukit Kretam, 17 May 1950.



Above: Banded palm civet (*Hemigalus derbyanus boiei*), adult female. Sapagaya Forest Reserve, 20 July 1950. Below: Marbled cat (*Felis marmorata marmorata*), adult female. Sapagaya Forest Reserve, 30 July 1950.



Clouded leopard (*Felis nebulosa diardi*), adult female. Near Mumiang, Trusan Kinabatangan, 19 March 1950. Photo courtesy G. S. Brown.



Above: Bearded pig (*Sus barbatus barbatus*), adult male. Bukit Kretam, 9 June 1950. Below: Barking deer (*Muntiacus muntjak pleiharicus*), adult male. Sapagaya Forest Reserve, 28 July 1950.



Mouse deer (*Tragulus javanicus klossi*). Above: Near Sandakan, 1950. Below: Sapagaya Forest Reserve, 14 July 1950.

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